JOURNAL OF DAIRY SCIENCE

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Vol. XXX, No. 10, October, 1947

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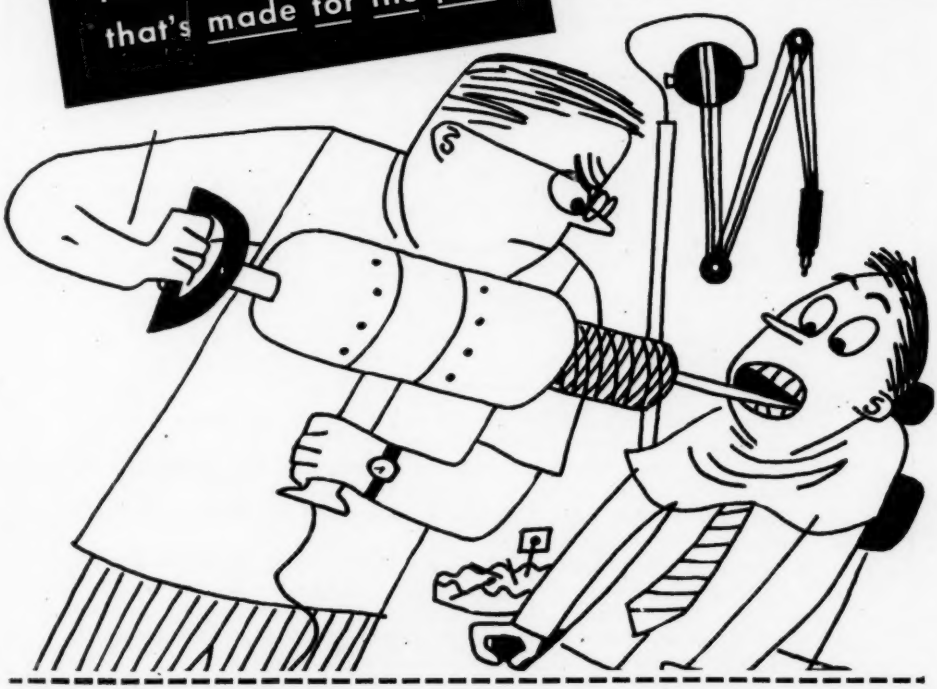

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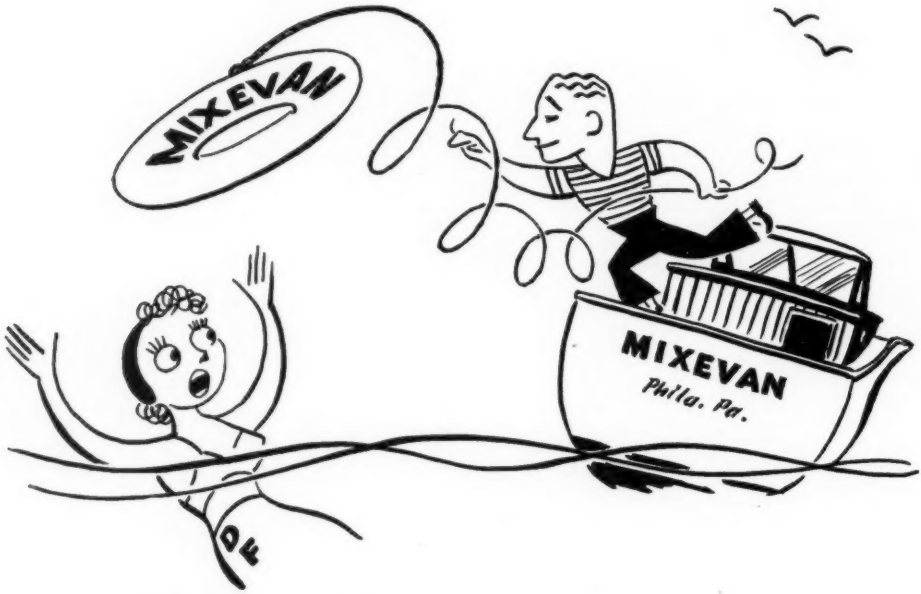

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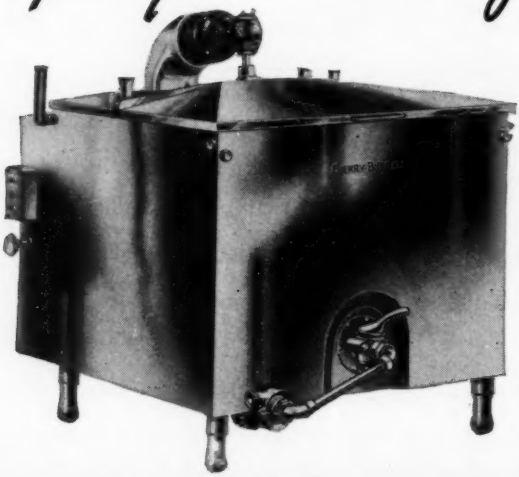

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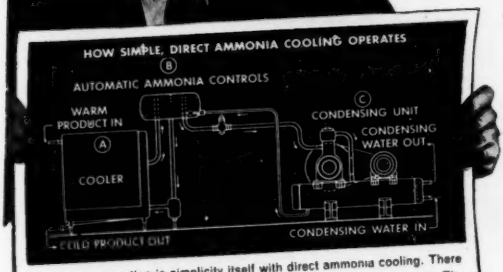

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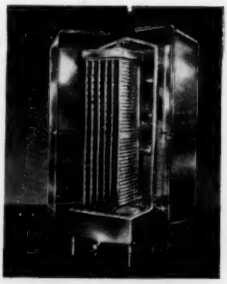

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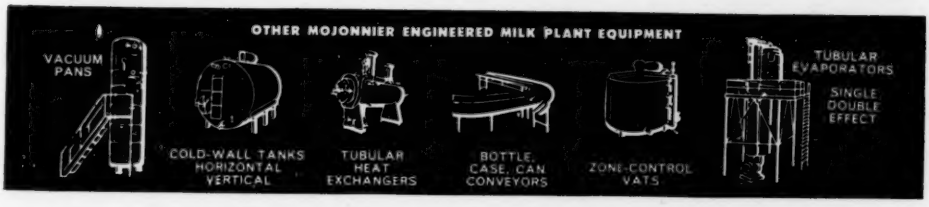

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JOURNAL OF DAIRY SCIENCE

VOLUME XXX OCTOBER, 1947 NUMBER 10

THE UTILIZATION OF THE MINERAL–ION EXCHANGE PRINCIPLE IN STABILIZING EVAPORATED MILK

D. V. JOSEPHSON AND C. B. REEVES

Department of Dairy Technology, Ohio State University, Columbus

Prior to the classic works of Sommer and Hart (4, 5, 6) the problem of heat coagulation in evaporated milk was little understood. These workers demonstrated the importance of salt relationships in the mechanism of the heat stability of this product and, supported by extensive investigations, presented the well-known "salt balance" theory of protein stability. This theory was based on an assumption that a delicate balance exists between calcium and magnesium ions, on the one hand, and citrates and phosphates on the other. An unbalanced system, one way or the other, would cause coagulation during sterilization. These investigators further demonstrated the importance of an optimum calcium-casein balance and suggested that the rest of the calcium was associated with citrates and phosphates. Their work, as well as commercial practice in recent years, has demonstrated that instability in evaporated milk almost invariably is due to an excess of calcium and magnesium.

The use of stabilizing salts has been a standard practice in evaporated milk manufacture for many years. Many investigators have studied the stabilizing effects of many salts, particularly sodium citrate and disodium phosphate (1, 5, 6, 7). For the most part, the industry today employs disodium phosphate to control the heat stability of evaporated milk, a practice which has been necessary for the successful year-around manufacture of the product.

In 1933 Lyman *et al.* (3) reported that salt readjustments could be made in milk by treating the product with suitable base exchange silicates. Later, Lyman (2) was issued a patent on the use of this process in producing soft curd milk. The method called for the removal of a part of the calcium and phosphorus from milk by means of a base exchange process which consisted of a filter bed of synthetic zeolite sand acting in the sodium cycle.

Since the instability of evaporated milk during sterilization is due primarily to an excess of calcium and magnesium ions, it appeared logical that some system employing the ionic exchange principle might be applied to

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the problem of stabilizing this product. Such an investigation was undertaken and carried out over a period of 1 year.

EXPERIMENTAL PROCEDURE

Since excess calcium and magnesium ions primarily are responsible for the instability of milk proteins during the sterilization of evaporated milk, the need for a cationic type of exchanger with a high degree of specificity for polyvalent cations is obvious. The exchanger used in the investigation was a resinous type known as Amberlite IR—100. Preliminary trials demonstrated that other cation exchangers, such as the carbonaceous type, might have been used with equivalent success. When acting in the sodium cycle, these exchangers effect an efficient removal of calcium and magnesium from milk without materially affecting the anion concentration.

In processing the milk by the above mineral-ion exchange process, hereafter called the M.I.E. process, several variations were investigated. Both raw whole milks and skim milks were treated and employed in the evaporated milk experiments. Mechanical and technical difficulties resulting in the loss of butterfat in the filter beds made the treatment of skim milk the more effective and practical procedure. After several exploratory trials, the advantage of using a dried M.I.E.-treated skim milk was demonstrated, and most of the later trials were conducted with this material.

In passing milk through the cation exchanger, about 60 per cent of the calcium was removed. When dried by the spray process, the resulting powder was white, fluffy, and very soluble in water.

In this particular exchange process the pH of the milk was increased to approximately 8.0. In some cases the pH was adjusted back to 6.6 by means of a hydrogen exchanger so that a comparison of the effectiveness of these products could be made in evaporated milk.

The M.I.E.-treated milks were employed in (a) fluid, (b) concentrated (26.2 per cent total solids), and (c) powdered forms, and were added either to the fluid untreated milk before forewarming or to the concentrated milk prior to filling and sterilizing. All evaporated milks were standardized to 26.2 per cent total solids with fat-to-total solids ratio of 1 to 3.3.

Since the amount of "correction" of the salt equilibrium (removal of excess calcium) was very slight in most milks, only a small percentage of the fluid required treatment to produce optimum stability during sterilization. When the bulk lots of fluid or concentrated milk were treated with various percentages of M.I.E.-processed milk, this percentage was calculated and expressed as "per cent of treated milk added". In other words, a 1,000 lb. batch of fluid milk (or equivalent) testing 12.7 per cent total solids required the addition of 10 lb. of M.I.E.-treated fluid or about 1.3 lb. of M.I.E.-treated powder to effect a 1 per cent treatment of the untreated fluid or concentrate.

When additions of M.I.E.-treated fluid, concentrate, or powder were made at the hot well before forewarming, these additions were so made as to permit expressing the treatment on a fluid-fluid basis. Where concentrated M.I.E.-treated milk was used in treating untreated concentrated milk before filling and sterilizing, both concentrates were standardized to the same total solids content (26.2 per cent) and subsequently combined in various ratios. When the M.I.E-treated powders were employed in experiments with concentrated milk, the powder was first reconstituted to 26.2 per cent total solids and then combined with the untreated product on a concentrate-concentrate basis.

The fluid milks used in these experiments were taken from supply tanks containing about 20,000 lb. of average mixed milk. The initial experiments were conducted during the months of January to May, when milk is most unstable to heat.

All milks were forewarmed at 203° F. for 15 minutes with direct steam prior to condensing. The concentrated product was homogenized at 3,000 lb. per square inch in a Cherry-Burrell Viscolizer and then pumped over a surface cooler and cooled to about 40° F. After testing and standardizing to 26.2 per cent total solids, the product was canned in standard 14.5-ounce cans, sealed, and sterilized at 240° F. for 15 minutes in a case-size (45-can) Fort Wayne laboratory sterilizer. After cooling with cold water, the cans were removed for immediate examination and subsequent storage. In all experiments a sufficient number of cans of each type of treatment were prepared so that storage studies could be continued for 1 year.

In order to evaluate the M.I.E. treatment in terms of salt additions of comparable effectiveness, a number of direct comparisons were made. This necessitated the conducting of pilot trials on untreated concentrated milk to determine the optimum amount of stabilizing salt required to effect optimum stability during sterilization. Disodium phosphate ($Na_2HPO_4 \cdot H_2O$) was used as the stabilizing salt in all of these trials and is expressed in the conventional "ounces of salt per 1,000 lb. of concentrated milk" basis.

After sterilization and during storage at room temperature, the evaporated milks were examined for color, body, viscosity, pH, flavor, and butterfat separation. During storage the cans were not turned and samples were examined after 1, 2, and 4 weeks of storage. Subsequent examinations were made after 2, 4, 8, and, in some cases, 12 months of storage.

EXPERIMENTAL RESULTS

In the course of these investigations 16 separate experiments were conducted, several of the early trials being of an exploratory nature.

The first two trials involved the addition of concentrated M.I.E.-treated milk to the untreated concentrated milk before sterilization. Whereas the batches of concentrated milk in these two trials required 7.3 and 15.7 ounces,

respectively, of disodium phosphate to produce optimum stability in the product, the addition of 2.5 and 6.0 per cent, respectively, of the M.I.E.-treated concentrate produced comparable results. Viscosity, body, pH, and flavor characteristics of the evaporated milks made by the two methods were very similar and compared favorably with the commercially available products.

Fluid Versus Concentrate Treatments

TABLE 1

A comparison of the stability of evaporated milks made with M.I.E. treatments in the hot well and after concentration (random trial)

Sample no.	Type of treatment	24 hr. after sterilization				
		pH	Viscosity, Borden-flow-meter (sec. at 60° F.)*	Body	Color	Flavor
1	Control, untreated	6.28	T.V.†	Curdy Grainy	Normal	.....
2	Control, salt-corrected‡	6.34	T.V.	Smooth Heavy	Normal	Normal
3	2.5% M.I.E.-treated fluid§	6.35	181	Smooth	Normal	Normal
4	5.0% M.I.E.-treated fluid	6.38	119	Thin	Normal	Normal
5	2.5% M.I.E.-treated concentrate¶	6.33	T.V.	Heavy Sl. grainy	Normal	Normal
6	5.0% M.I.E.-treated concentrate	6.37	586	Heavy Smooth	Normal	Normal

* A viscosity between 250 and 400 seconds was considered ideal 24 hr. after sterilization.

† T.V., too viscous to measure with Borden-flow-meter. Viscosities over 600 seconds are not dependable.

‡ 15.7 ounces (per 1,000 lb. evaporated milk) disodium phosphate required for stability correction.

§ Percentage of treatment made at hot well before forewarming.

¶ Percentage of treatment made in concentrate before sterilizing.

The data presented in table 1 were taken from a representative trial in this series. The viscosity and body data show that only the equivalent of 2.5 per cent of the milk need be treated to correct the protein instability (requiring 15.7 ounces of disodium phosphate per 1,000 lb.) if the treated product is added to and forewarmed with the untreated milk. On the other hand, a 5.0 per cent (equivalent) treatment was required when the treated and untreated concentrates were combined just before sterilizing. In some of the other trials this difference was not so pronounced, and in one trial little difference was observed. Nevertheless, this series of trials showed a definite over-all advantage for the hot well treatment.

Evaporated milk frequently exhibits a very heavy or "livery" body after sterilization, but if not "grainy" the product "shakes out" into a smooth,

desirable product. In this particular trial (table 1) the control salt-corrected product became thinner on storage and maintained desirable body characteristics for 1 year. The M.I.E.-treated products in this trial varied considerably in this respect because of the range of treatments. All M.I.E.-treated products except sample 5 were highly satisfactory evaporated milks. The 2.5 and 5.0 per cent treatments of the fluid milk (samples 3 and 4) at the hot well were somewhat more than would have been needed for ideal body characteristics. On the other hand, in the concentrate-treated samples (nos. 5 and 6), 2.5 per cent was insufficient to produce stability, as is evidenced by the grainy body. A 5.0 per cent treatment of the concentrate gave excellent results, and after 1 year in storage the quality of this sample was superior to any other in this experiment.

The Use of M.I.E. Milk Powder

As previously stated, the treatment of raw whole milk by the M.I.E. process was considered impractical because of mechanical difficulties in processing. Furthermore, there was no advantage in having the butterfat present during treatment, and in the powdered M.I.E. product the butterfat was additional bulk. Therefore, the last nine experiments were conducted employing M.I.E.-treated fluid, concentrate, and powdered skim milk products as stabilizing treatments for evaporated milk. Since the powdered products gave results comparable to those obtained with the same milk in fluid or concentrated forms and since the powder would be more practical for the small evaporated milk manufacturer, special emphasis was given to this phase of the problem.

Two trials conducted with M.I.E.-treated whole milk powder revealed that the powder was very effective in stabilizing evaporated milk. The powder was reconstituted to 26.2 per cent total solids and combined with the regular concentrated milk before sterilizing. One lot of the fluid was treated at the hot well before forewarming in order to compare these methods further. The results of one of these trials are presented in table 2.

A comparison of the concentrate (added just prior to sterilization) and fluid (hot well) treatments again reveals an advantage for the fluid method of M.I.E. stabilization. Had the percentage of fluid treatment been lower, a higher and more desirable viscosity would have resulted. In several trials where a lower-than-optimum viscosity was obtained with M.I.E.-treated milks at 240° F. sterilization, a desirable result was obtained by increasing the sterilizing temperature to 242–244° F. and holding for the conventional 15 minutes. In a number of comparisons where the M.I.E.- and salt-treated samples were sterilized at various temperatures, the body and viscosity characteristic of M.I.E.-treated samples appeared to be more stable to temperature change than the salt-corrected samples.

Other trials employing M.I.E.-treated skim milk powder gave very

TABLE 2

The use of M.I.E.-treated whole milk powder in stabilizing evaporated milk

Sample no.	Type of treatment	24 hr. after sterilization				
		pH	Viscosity, Borden-flow-meter (sec. at 60° F.)	Body	Color	Flavor
1	Control, untreated	6.29	T.V.†	Curdy Grainy	Normal	.....
2	Control, salt-corrected*	6.28	235	Smooth	Normal	Normal
3	2.5% M.I.E.-treated concentrate	6.30	258	Smooth	Normal	Normal
4	5.0% M.I.E.-treated concentrate	6.33	145	Thin	Normal	Normal
5	2.5% M.I.E.-treated fluid	6.30	179	Good Sl. thin	Normal	Normal

* 10.4 ounces (per 1,000 lb. evaporated milk) disodium phosphate required for stability correction.

† Too viscous to measure.

similar results, so that a process involving the treatment of skim milk and its subsequent use as a fluid, concentrate, or powder seems most practical.

The Effect of the pH of M.I.E.-Treated Skim Milk on Its Efficiency as a Stabilizer of Evaporated Milk

Since increasing the pH of milk by the mere addition of a base has some stabilizing effect on the heat stability of milk proteins, the effect, if any, of

TABLE 3

The effect of pH adjustment of M.I.E.-treated skim milk on its stabilizing efficiency

Sample no.	Type of treatment*	24 hr. after sterilization				
		pH	Viscosity, Borden-flow-meter (sec. at 60° F.)	Body	Color	Flavor
1	Control, salt-corrected†	6.36	600	Very heavy Smooth	Normal	Normal
2	1.5% M.I.E. at pH 6.7	6.36	390	Heavy Good	Normal	Normal
3	3.0% M.I.E. at pH 6.7	6.35	187	Good	Normal	Normal
4	1.5% M.I.E. at pH 8	6.36	310	Heavy Good	Normal	Normal
5	3.0% M.I.E. at pH 8	6.37	100	Thin	Normal	Normal

* All M.I.E.-treated materials added at hot well before forewarming.

† 6.2 ounces disodium phosphate required for stability correction of 1,000 lb. evaporated milk.

the somewhat increased pH of the M.I.E.-treated milk solids was determined. A portion of a lot of M.I.E.-treated skim milk was re-treated in a hydrogen exchanger so as to adjust the pH from 8.0 to 6.7. The two lots were dried by the spray method and the powders used in stabilizing evaporated milk. Two trials were made on successive weeks when quite unstable winter milk was available. Since little butterfat was present in the powder, the "percentage of treatment" was on a solids-to-solids basis.

The results obtained in both of these trials were very similar and confirmed the fact that the product at pH 8.0 had only a slight advantage over the one in which the pH was adjusted back to 6.7 (table 3). The data also show that the use of the unadjusted material has very little effect on the pH of the finished evaporated milk. This observation supports the data presented in tables 1 and 2, as well as the data obtained in numerous other trials.

The viscosity of sample 1 (control, salt-corrected) was very high after sterilization. It became much less viscous after 1 week in storage and, together with samples 2 and 4, finished a 1-year storage period in very fine condition. Samples 3 and 5, which actually were overstabilized, were thin and showed considerable fat separation (creaming) after 4 months and 1 month, respectively.

The Application of the M.I.E. Treatment to Evaporated Milks with Higher-Than-Normal Solids Content

As the percentage of total solids in evaporated milk is increased, the tendency toward coagulation during sterilization becomes progressively more pronounced. Moreover, evaporated milk containing more than 26.2 per cent total solids will exhibit darker color, more astringent flavor, lower pH, and greater tendency toward mineral deposits after sterilization.

A series of trials were conducted in which the total solids content of evaporated milks was varied from 26.2 to 34.0 per cent. These trials were made in early May when milk was becoming more stable to heat. At this particular time the conventional 26.2 per cent total solids product could be corrected with 2 ounces or less of disodium phosphate per 1,000 lb. of concentrate. In one trial where the concentration was carried to 34.0 per cent total solids, 47 ounces of disodium phosphate per 1,000 lb. of product was required to produce stability in the sterilized product. A parallel trial in the same experiment, involving the M.I.E. treatment of the fluid milk at the hot well, showed that by treating 5.0 per cent of the product, comparable viscosity and body characteristics could be effected.

Two other comparisons at somewhat lower concentrations demonstrated that a comparably small percentage of M.I.E.-treated product was highly effective in controlling the coagulating tendencies of high-solids evaporated milk.

This particular phase of the study is being given further consideration and will be reported upon in the near future.

The Effect of M.I.E. Treatment on the Calcium, Phosphorus, and Ash Content of Evaporated Milk

Calcium and phosphorus are very important nutritional factors in milk. Any process or treatment that would disturb either the concentration or particularly the ratio of these constituents in milk would be undesirable. Therefore, it was of interest to demonstrate the magnitude of change in the concentration of these elements in evaporated milk as a result of M.I.E. treatment.

The data presented in table 4 show the calcium, phosphorus, and ash

TABLE 4

The calcium, phosphorus, and ash content of M.I.E.- and disodium phosphate-corrected evaporated milks (all data corrected to 26.2 per cent total solids)

Expt. no.	Type of stabilizing treatment	Amount of treatment	Calcium (%)	Phosphorus (%)	Ash (%)
1	Disodium phosphate	7.3 oz.	0.2523	0.2220	1.546
	M.I.E.	5.0%	0.2438	0.2203	1.530
4	Disodium phosphate	8.3 oz.	0.2541	0.2125	1.529
	M.I.E.	2.5%	0.2509	0.2094	1.526
5	Disodium phosphate	18.7 oz.	0.2508	0.2093	1.554
	M.I.E.	5.0%	0.2401	0.1998	1.468
6	Disodium phosphate	10.4 oz.	0.2353	0.2034	1.487
	M.I.E.	2.5%	0.2532	0.1977	1.507
8	Disodium phosphate	8.3 oz.	0.2509	0.2062	1.521
	M.I.E.	3.0%	0.2535	0.1985	1.469
9	Disodium phosphate	2.0 oz.	0.2555	0.2098	1.529
	M.I.E.	0.5%	0.2551	0.2023	1.533
10	Disodium phosphate	2.0 oz.	0.2430	0.2053	1.509
	M.I.E.	0.5%	0.2452	0.2455	1.505
11	Disodium phosphate	10.4 oz.	0.2505	0.2275	1.537
	M.I.E.	2.0%	0.2518	0.2173	1.547
12	Disodium phosphate	6.2 oz.	0.2438	0.2064	1.474
	M.I.E.	1.5%	0.2477	0.2092	1.496

analyses of evaporated milks made in 9 of the 16 experiments. The data given in each case are for only the optimum M.I.E. and disodium phosphate treatments.

The calcium content of the evaporated milks was altered only insignificantly by the M.I.E. treatment. Similarly, the ash content is essentially the same. The somewhat higher values found for phosphorus in the salt-corrected samples undoubtedly are due to the added disodium phosphate. From the data presented here it can be concluded that the amount of M.I.E. treatment required to stabilize evaporated milk has no significant effect upon the calcium, phosphorus, and ash content of the finished product.

DISCUSSION

Treatment of a small percentage of a given lot of milk by the M.I.E. technique is an effective means of stabilizing evaporated milk. The finished

product made with M.I.E.-treated milk compared favorably with that obtained with the conventional "salt correction" method and was particularly outstanding in cases where very unstable milk was concerned. After storage for 1 year, evaporated milks made by the two methods were found to be essentially the same with respect to color, flavor, viscosity, pH, and fat separation. In no case was it found impossible to stabilize the milk by either the salt or the M.I.E. method during the season from January to May when milk usually exhibits its maximum instability.

M.I.E.-treated fluid milk and the same product condensed or dried were equally effective in stabilizing evaporated milk against coagulation during sterilization. Treatment of the fluid at the hot well before forewarming generally was more effective than the method of treating the concentrate just before filling and sterilizing.

Normal M.I.E.-treated milk exhibits a pH of approximately 8.0. By restoring the pH to approximately normal (6.7) with a hydrogen exchanger, the effectiveness of the product was altered very little, thereby demonstrating that the somewhat elevated pH of the product contributes little to its stabilizing effect. The use of unadjusted M.I.E. products in concentrations required to stabilize evaporated milk had essentially no effect on the pH of the finished product.

The stabilization of evaporated milk with M.I.E.-treated milk has no significant effect on the calcium and phosphorus content of the product. The amount of treatment required to stabilize most evaporated milks is so small that its effect scarcely can be detected by conventional calcium analyses.

Preliminary trials demonstrated that where almost prohibitive amounts of disodium phosphate were required to stabilize high total solids (34.0 per cent) evaporated milk, a treatment of only 5.0 per cent of the original fluid effected a desirable result.

The mechanism by which the M.I.E. principle acts in the stabilization of evaporated milk could not be determined definitely from the data taken in this study. However, since instability of evaporated milk generally is attributed to excess calcium and magnesium ions, the re-establishing of a more favorable ionic equilibrium by the physical removal of these excess ions by M.I.E. treatment appears to be the most logical explanation.

CONCLUSIONS

1. The mineral-ion exchange process as employed in these experiments with evaporated milk is capable of stabilizing the product against coagulation during sterilization at 240° F. for 15 minutes.

2. This process has been found effective in stabilizing milks exhibiting a wide range of instability to heat.

3. The addition of optimum quantities of mineral-ion exchange-treated

milk to evaporated milk before sterilizing imparts characteristics similar to those obtained when the product is stabilized with salts.

4. Under average conditions where a product requires 2 to 6 ounces of stabilizing salt per 1,000 lb. of concentrate to produce stability, the same correction can be effected by treating from 0.5 to 2.0 per cent of the original milk by the mineral-ion exchange process.

5. The addition of the mineral-ion exchange-treated milk at the hot well before forewarming produces somewhat greater efficiency of stabilization than addition later.

6. The mineral-ion exchange-treated milk can be used as a fluid, concentrate, or powder with almost equal effectiveness.

7. Preliminary trials suggest that the mineral-ion exchange method of stabilization may be very effective in the manufacture of high total solids (32–34 per cent) evaporated milk.

8. The utilization of this process in the manufacture of evaporated milk has only an insignificant effect on the calcium and ash content of the product.

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SEASONAL VARIATIONS IN HOURS OF DAYLIGHT ASSOCIATED WITH FERTILITY LEVEL OF CATTLE UNDER NATURAL BREEDING CONDITIONS

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Losses due to sterility or low fertility amongst livestock in North America amount to millions of dollars annually. Though this fact is recognized by most workers in the field, controlled investigations have not yielded evidence to suggest that eliminating these losses is an easy matter soon to be achieved (2).

Sterile animals are identified readily in most dairy herds, but inefficient reproducers may be more difficult to expose and, in the aggregate, may contribute fully as much to monetary loss. The rapid growth of artificial breeding has served to emphasize the importance of the differences in relative fertility among dairy cattle and to focus attention on this problem.

From the records accumulating on thousands of cattle in the New York artificial breeding program it was believed that it might be possible to obtain evidence on the causes of the varying levels of fertility observed. The records are obtained from herds operated under a variety of conditions in all agricultural counties of the State. The data first were studied with the objective of determining the effect of various factors on fertility results. Certain inseminating practices and regional problems were studied. However, it was evident immediately that certain major factors influenced fertility level. These factors, unless thoroughly understood, might obscure other influences, or bias data used for other studies.

The first factor of major importance was the age of the cattle concerned. Data on that problem were published by Tanabe and Salisbury (31). Later Mercier and Salisbury (20) studied what then appeared to be the second major influence, that of season on fertility level of dairy bulls; highly significant differences between months in fertility level were found. Earlier Salisbury (27) had found seasonal variations in semen quality which were not reflected in variations in fertility level. Others (8, 12, 15, 21, 23, 24, 30) had noted a seasonal trend in fertility level of cattle, which they attributed largely to variations in temperature. The results of these studies were so diverse that no general conclusions could be drawn.

Recently, Mercier (19) reviewed the published data concerning the monthly fluctuations in fertility level of cattle. From his review and his

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own data he suggested that the seasonal fluctuations observed were not random variations, but followed definite patterns associated with climatic factors, of which variations in length of daylight played an important part. Previously, as mentioned above, the seasonal fluctuations in fertility level of cattle had been attributed largely to variations in temperature. However, it has been shown that light is the primary agent regulating the breeding behavior of many species of birds and lower mammals. This subject has been reviewed at length by other investigators (3, 4, 6, 18, 26). Evidence is yet to be produced to show that light does not influence fertility level in cattle.

The authors recognized that the definite experimental demonstration of the influence of light variations on fertility level of cattle would involve an enormous outlay of time and effort. In an experiment of this kind, more animals would be required to produce valid conclusions than usually are considered necessary. For direct proof of the theory it would be necessary to show that fertility level was modified by light manipulations. To demonstrate the reasons for such modifications of the fertility level by light manipulations, the morphological and physiological changes in the primary reproductive organs, as well as the hormone balance of the entire body, would have to be studied minutely.

As adequate facilities were not available for direct experiments on the question, it was felt that an indirect approach might reveal definite facts from which the importance of light variations on fertility level could be assayed. Thus, a detailed statistical study was made of Mercier's data (19), and additional evidence was obtained from the records of the New York Artificial Breeders' Cooperative, Inc.

The present report deals with a study of the conception rate of cattle under natural breeding conditions in Eastern Canada. It was undertaken because the authors felt that the possible detrimental effect of extreme temperatures on reproduction would be minimized because of the cool Canadian summers and the wintering of cattle in warm barns. On the other hand, they believed that the effect of light, if involved, would be emphasized because of the extreme length of the summer days and the shortness of the winter days.

MATERIALS AND METHODS

Three main points considered in the selection of herds to provide breeding records for this study were the latitude at which the farms were situated, the similarity in management practices, and the reliability of the available breeding records.

The purebred herds of the three following institutions, containing cows of the Ayrshire, Holstein, and beef and dual-purpose Shorthorn breeds, were selected: The College of Agriculture of MacDonald, Quebec, and the Experimental Stations of Ste-Anne-de-la-Pocatiere, Quebec, and Kapuskas-

ing, Ontario. Only a few females were brought into the herds during the period covered in this study, 1919–1944. In all herds there was a tendency to use sires of various ages, and no close-breeding systems were followed. Abortion waves occurred in two herds. Before 1935, reactors were eliminated; after that, the policy was to isolate females that aborted. In order to avoid bias due to these troubles, all records used were from cows which conceived prior to the fifth service.

The farms were located almost exactly 2° of latitude apart, one at 45°, one at 47°, and the other at 49°. These differences had little effect on monthly mean daylight hours, the northernmost station having approximately one-half hour less of daylight during January and the same amount more during June. As a consequence the monthly average number of daylight hours and hours of sunshine varied somewhat from station to station, but this variation was unimportant in comparison with the extreme change throughout the year. The monthly mean number of daylight hours varied from 8.2 hours in December to 16.0 hours in June. At no time during the year did the mean monthly outside temperature at any station reach 70° F., which is well below the point of hyperthermal rise in body temperature.

The breeding records for each herd were sorted by month of service, and the number of successful services determined for each month. The data were tabulated as the per cent of successful services and were so used in this investigation. However, in order to make the results comparable with others published, they are expressed as services per conception.

The monthly per cent of successful services for each herd was considered as a single observation. Months were grouped into seasons: winter months being December, January, and February; spring months, March, April, and May; summer months, June, July, and August; and fall months, September, October, and November. Analyses of variance and covariance techniques, as described by Love (17), were used to colligate the evidence. In the first case the per cent of successful services was used, while in the second, the independent variable was the number of services and the dependent variable the number of conceptions. In the use of each statistical technique no significant herd × season interaction was observed. Thus, in each analysis the entire remainder including the primary interaction variance was used for testing the statistical significance of "herds" and "seasons".

RESULTS

The data grouped by season and herd are presented in figure 1. No significant differences in fertility level between herds were found by either method of analysis, but both methods showed a significant difference in fertility level between the seasons at the 5 per cent level of probability. These data show that fertility level as measured by the per cent of successful services was highest in summer and lowest in the winter and spring in these

Canadian herds. A study of the monthly per cent of successful services for the three herds suggested a definite trend. The poorest conception rate was obtained during the month of February and the best during the month of July, some time after the shortest and the longest day of the year, respectively.

For comparative purposes a survey of the number of services per conception in cattle obtained at various locations in the Northern Hemisphere is presented in table 1. The information published by Clapp (9) for the Cornell University dairy herd shows the same trends as do the data reported here and by Mercier (19). Except for the data of Dawson (10), Liang

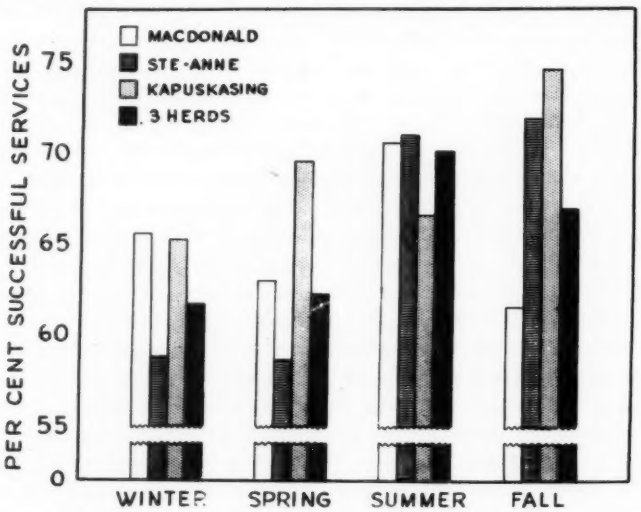

FIG. 1. Seasonal variations in fertility level of three herds in Eastern Canada.

[Phillips *et al.* (23)], and Seath *et al.* (30), which are largely from the southern portion of the Hemisphere, there is a tendency for the number of services per conception to decrease from February on through the spring until the days begin to shorten and the hot weather of summer supervenes.

The observed trend suggested that increased length of day or increased temperature, up to an optimum temperature, might beneficially influence reproduction in cattle. In Mercier's data (19) no decrease in fertility level during the summer was observed. In fact, the variations in fertility level seemed to vary directly with the length of daylight, the hours of sunshine, and the outside temperature, there being a lag of some time before the maximum effect was reached.

The relationship between each of these climatic factors and the average fertility level of the three herds was determined. To get an idea of the

TABLE 1

Seasonal variation in conception rate of cattle under natural conditions
(services per conception)

Month	Dawson (10) 8 states	Morgan & Davis (21) Nebr. 1896–1934	Erb *et al.* (12) Ind. 1920–'40	Hilder *et al.* (15) Md. 1919–'42	Clapp (9) N. Y. 1929–'45	Mercier (19) E. Canada 1919–'44	Phillips *et al.* (24) Md. 1935–'42	Seath *et al.* (30) La. 1923–'40	Liang (23) S. China
Jan.	2.50	2.08	1.54	2.57	2.18	1.51	1.93	Winter	Dec.–Feb.
Feb.	2.34	2.25	1.69	2.81	2.29	1.67	1.89	2.5*	1.71
March	2.45	2.46	1.41	2.80	2.05	1.54	1.80	1.5†	March–May
April	2.26	2.16	1.53	2.65	2.03	1.56	1.68	Spring	1.96
May	2.54	2.20	1.35	2.64	1.99	1.66	1.71	2.8*	
June	2.63	2.10	1.47	2.36	1.96	1.43	1.82	1.9†	June–Aug.
July	2.31	2.07	1.66	2.94	1.90	1.41	2.40	Summer	2.37
Aug.	2.48	2.78	1.72	2.88	2.20	1.43	2.45	3.4*	
Sept.	2.56	2.85	1.60	2.82	2.11	1.46	2.38	2.4†	Sept.–Nov.
Oct.	2.42	1.99	1.60	2.52	2.13	1.49	1.98	Fall	1.66
Nov.	3.08	2.09	1.57	2.64	2.26	1.50	1.85	2.7*	
Dec.	2.50	1.94	1.64	2.52	2.26	1.52	1.82	1.4†	
Av.	‡$\frac{2982}{1197}$ = 2.49	$\frac{2979}{1375}$ = 2.16	$\frac{1440}{922}$ = 1.56	$\frac{9181}{3439}$ = 2.67	$\frac{4250}{2019}$ = 2.11	$\frac{3543}{2322}$ = 1.53	$\frac{1135}{584}$ = 1.94	.....	$\frac{795}{430}$ = 1.85

* = Expt. herd.
† = Univ. herd.
‡ = $\frac{\text{Services}}{\text{Conceptions}}$.

length of the apparent lag effect, the correlation coefficients between the per cent of successful services for one month and the average monthly values for temperature, length of day, and number of hours of sunshine for the month corresponding to and of the first, second, third, and fourth month prior to mating were calculated. The correlation coefficients are shown in table 2.

The relationship between fertility level and each of the three climatic factors was approximately of the same magnitude. The correlation coefficients for the second month prior to mating, in general, were the highest. As hours of sunlight are a function of the length of day, and as Olson (22) has reported that lack of direct sunshine had no measurable effect on reproduction in cattle, the authors have eliminated this item from further

TABLE 2

Correlations between the conception rate and the monthly averages for climatic factors for the month corresponding to and the months prior to mating

Correlations between fertility level and:	Months for climatic factors				
	Corresponding	Prior to mating			
		First	Second	Third	Fourth
Temperature	0.588*	0.732†	0.692†	0.441	0.220
Day-length	0.275	0.604*	0.731†	0.668†	0.460
Daily sunshine hours	0.346	0.573*	0.697†	0.603†	0.388

* Significant at the 5% level of probability.
† Significant at the 1% level of probability.

consideration. Partial correlations for the second month prior to mating, using the individual observations for each herd, indicated that length of daylight and not temperature change was the more important factor associated with the conception rate under Canadian conditions. The partial correlation coefficients were 0.352 and 0.017, respectively, the first being significant at the 5 per cent level of probability. The results suggest that longer daylight has a beneficial effect on the conception rate of cattle in Eastern Canada.

That this observation may have wider application is indicated by other evidence. In England, Hammond (14) and Sanders (29) observed that cows calving in spring and bred in summer, especially in the northern districts of the country (14), required less time to get in calf than those calving in fall and bred in winter. Plum and Lush (25) found that heifers in Iowa bred in spring and summer calved at an earlier age than those bred in late fall and winter. In a similar study of the age of Ayrshire heifers in the United States calving for the first time during 1942–1945, Salisbury and Mercier (28) observed the same trend. Furthermore, in their data, comparison of the ages of the heifers calving in the states below the 40° of latitude, none of which are in the extreme South, and those calving in the states north of that parallel showed that the monthly average age at

first calving varied more for the group calving in states north of the 40° of latitude than for the group calving in states south of that latitude. Huntington (16) has observed a similar increase in the amplitude of seasonal conception curves in human beings in the United States and Canada as the population areas studied shifted from the Equator towards the North. It would appear that at high latitudes heifers as well as mature cows are somewhat less fertile during periods of the shortest length of day and, as a consequence, conception and calving are delayed.

DISCUSSION

Dawson (10), studying the fertility of aged bulls used at various locations in the United States, found that the relative fertility of sires used at southern stations was 36 per cent as compared to 49 per cent for sires used at northern and western locations. Seath *et al.* (30) in Louisiana and Liang [Phillips *et al.* (23)] in southern China attributed the poor results secured during summer and spring (see table 2) to high environmental temperature. Although this interpretation may explain satisfactorily the contrasting seasonal difference between their results and those of the authors, it does not explain adequately the rather uniformly low monthly conception rate of aged sires in the south of the United States (10).

It is known that the seasonal variation in day-length becomes less and less, the winter days being relatively longer and the summer days shorter, as one approaches the Equator. For instance, the day-length averages for the months of June and December are, respectively, 16.0 and 8.2 hours in Eastern Canada (1) and 14.1 and 10.3 hours in Louisiana (33). The lesser variation in length of daylight may account somewhat for the relatively good winter results reported at low latitudes (10, 23, 30).

That level of nutrition is probably not a controlling factor in the increased breeding efficiency observed as spring advances is indicated by the fact that in the north the gradual change is underway before pasture becomes available. Also, the evidence suggests that confining cows in stanchions is not responsible for the lower breeding efficiency observed in winter. Webster (35) from New Zealand reported that the majority of barren cows kept on pasture the year around bred successfully, most of the time at the first attempt, when carried over the winter to the following spring.

Though the action of light on reproductive activity of vertebrates is not entirely clear, it is known to act on the pituitary and possibly on other areas of the midbrain through the eye, retina, and the optic nerve (3, 4, 6, 18, 26). Fiske (13) has shown that light stimulates the pituitary of the female rat to produce and release follicle-stimulating hormone. Conversely, lack of light favors an increase in the production of luteinizing hormone.

Since the relationship of temperature to the reproductive processes is not thoroughly understood, the effect of high temperature on the semen

production of males may be only a secondary effect rather than a primary one. There is direct evidence that temperature affects the function of the thyroid gland in the rat (11) and in the ram (7) and also the gonadotropic potency of the anterior pituitary in the ground squirrel (36). Furthermore, it has been shown that in the rat (32) the pituitary controls the rate of formation and the release of thyroxin into the circulation, and that it acts on the gonads of certain species of fish (34) through the thyroid. Seasonal variations in the amount of thyrotropic hormone in the blood of cocks and ducks, associated with changes in the activity of the thyroid and the testis, were reported by Benoit and Aron (5).

While these reports strongly suggest that the seasonal variations in reproductive efficiency reflect primarily pituitary and, secondarily, thyroid activity, more evidence is needed before definite conclusions may be drawn.

The results of research published by others and the work reported here lead the authors to conclude that light plays an important role in controlling the breeding efficiency of cattle. Obviously, further studies should be made to determine any specific effect of light and temperature on reproductive activity of cattle of various ages and to modify, if possible, these two environmental factors or to change management practices in order to improve conception rate, especially of cows bred to calve in the fall.

SUMMARY

In a study of three herds of cattle located at different latitudes in Eastern Canada, the lowest per cent of successful services was obtained during winter and spring and the highest during summer and fall. The differences in fertility level between herds were not significant statistically but those between seasons were significant at the 5 per cent level of probability.

The average monthly conception rate of the three herds was significantly correlated with the monthly average length of daylight, there being a lag of approximately 1 to 2 months before the maximum effect was reached. Temperature changes had no measurable direct effect on fertility level under the existing conditions.

The authors believe that at high latitudes variations in length of daylight measurably influence the fertility level in cattle.

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THE RELATION OF PER CENT TOTAL SOLIDS IN SEPARATED MILK AND PER CENT FAT IN WHOLE MILK TO ATMOSPHERIC TEMPERATURE

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During recent years, the general use of continuous processing methods and various types of automatic process controllers has reduced or eliminated many elements responsible for deviations from quality standards. This has resulted in a greater appreciation of the significance of variations in the composition of milk both on a day-to-day and on a seasonal basis.

Daily variations in the fat test of milk also are of interest to the dairyman who occasionally may have special fat tests made during a period of only a few days. Dr. E. W. Bird of Iowa State College called the author's attention to the fact that although numerous reports have been published establishing several reasons for variations in fat test, the significance of day-to-day variations in atmospheric temperature has not been stressed. The data presented in this report are intended, therefore, to demonstrate that variations in atmospheric temperature from one day to the next are sufficiently significant to be of major importance to the plant operator and the dairyman.

LITERATURE

Several studies have shown that the temperature affects the fat percentage of milk. Generally, this conclusion has been reached on a seasonal basis rather than on a day-to-day basis. During March and April, 1922, however, Ragsdale and Brody (3) compared the average fat test of the milk from ten cows over a 24-hour period with the mean atmospheric temperature of the same 24 hours and concluded that there is roughly about 0.2 per cent increase in fat for each 10° F. decrease in temperature.

Hays (2), working with Ragsdale and Brody, carried out a more comprehensive study. Daily data for fat tests and air temperatures were collected for 258 days. The environmental temperatures ranged from 85.5 to 24.5° F., and the average fat tests ranged from 3.171 to 3.600 per cent. This increase in fat test amounted to 0.079 per cent for each 10° F. lowering of the temperature. However, Hays did not consider these results as significant as those obtained on two Jersey cows which were maintained for 4- to 8-day intervals in controlled temperature rooms. The result of these trials indicated a rise of 0.189 per cent fat for each 10° F. lowering in temperature.

Regan and Richardson (4) found that at 80 or 85° F., depending upon the breed, a pyrexial point was reached where animals no longer were able

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to maintain heat balance. This probably explains some of the adventitious results secured by Hays on his trials with two Jersey cows. Regan and Richardson further noted that above the pyrexial point many changes were observed in the chemical constituents of milk, such as lowering of casein and solids-not-fat, increase in fat and pH, depression of the freezing point, a longer rennet coagulation time, and lower per cent volatile acids and higher per cent unsaturated components of the butterfat secreted.

Gaalaas (1) reported a definite relationship between the body temperature of the cows and the air temperature. The correlation coefficient was found to be $+0.57 \pm 0.0079$ for a total of 3,298 readings of body temperature. The correlation coefficient for respiration rate and air temperature was $+0.77 \pm 0.0048$.

Seath and Miller (5), studying the effects of both temperature and humidity on the body temperature and respiration, found that partial correlations between air temperature and body temperature (humidity held constant) were +0.674 for 1944 and +0.534 for 1945 on 36 Holsteins and 16 Jersey milking cows. The effect of humidity on body temperature was of minor importance. Partial correlation coefficients for air temperature and respiration (humidity held constant) were +0.748 for 1944 and +0.353 for 1945. Humidity again was of minor importance.

Previous reports, therefore, indicate that: (a) a general relationship exists between air temperature and the fat test of the milk; (b) after the pyrexial point has been reached, significant changes occur in the composition of the milk; and (c) a definite correlation exists between both body temperature and respiration rate of the cow and air temperature, with humidity playing an insignificant role.

METHODS

Total solids were determined by the Mojonnier method on a composite of several samples of separated milk taken at hourly intervals during the time of operation. The per cent total solids of the separated milk, rather than the per cent total solids in whole milk minus the per cent fat, was used as an index of the nonfat solids, since a more representative sample could be obtained. Since it was determined statistically that random sampling of one-seventh of the total amount of milk received would result in the desired accuracy, this amount of milk was cooled, held in storage tanks, agitated thoroughly, and sampled. Babcock tests were made on each of the several samples resulting, and these tests were averaged to obtain a figure representative of the daily fat test.

Mean daily temperatures were secured from the United States Weather Bureau located in Springfield, Missouri. Since all the milk is received within a radius of 40 miles of Springfield, it is felt that the mean daily temperature at Springfield is a fair representation of the temperature existing in this area. There is no conclusive evidence to support this statement,

but it is known that weather stations located between 50 and 70 miles away never have recorded temperatures at great variance with those recorded at Springfield.

Another factor very slightly affecting the accuracy of the figure given as mean daily temperature is that the hours used for arriving at this figure do not coincide with general milking times. Mean daily temperatures are based on hourly readings from 1:20 a.m. to 12:20 a.m. of the following day. It would have been more desirable for the purposes of this study to have the hours begin with 7:00 a.m. and end with 6:00 a.m. of the following day. This discrepancy of 5 or 6 hours, however, may be significant only during sharp changes in atmospheric temperature, which are rare. Very little difference between mean daily temperatures calculated by the two methods was found when hourly temperatures were recorded for a 10-day period. It should be emphasized that the mean daily temperature is the temperature of the day before the milk was received at the plant, *i.e.*, the air temperature at the time the cows were secreting milk.

The statistical methods used are those described by Snedecor (6). The mean daily temperatures were correlated with the mean daily fat tests of the whole milk received and of the mean daily total solids of the separated milk. A period of one month was chosen for convenience. Shorter periods would tend to reduce the effect of stage of lactation and would show less variation in the value of the correlation coefficient. Longer periods would increase the effect of stage of lactation and other factors affecting the composition of milk.

About 90 per cent of the cows in this area are Jerseys. As reported by Seath and Miller (5), this breed is more tolerant than the Holstein to high temperatures. Since the climate is temperate, cows are kept in barns only occasionally during short periods of severe cold. The milk received at the plant represents the combined volume of about 6,000 herds.

RESULTS

Table 1 shows the correlation coefficient, the regression coefficient, and the deviations from regression between the mean daily total solids and mean daily temperature for monthly intervals for the year 1946. Table 2 shows the correlation coefficient, the regression coefficient, and the deviations from regression between the mean daily temperature and the mean daily per cent fat in the whole milk for monthly intervals for the year 1946.

The results of this statistical study indicate that there is a relationship between atmospheric temperature and the per cent total solids in separated milk during 1946. The values of the correlation coefficient range from -0.062 to -0.758. The results also indicate a significant relationship between atmospheric temperature and the per cent fat in whole milk for the same year, the values ranging from -0.258 to -0.838. The fat test appar-

TABLE 1

The relation between the mean daily total solids in separated milk and the mean daily atmospheric temperature for 1946, calculated for monthly intervals

Month	Correlation coefficient	Regression coefficient	Deviation from regression
January	− 0.062	− 0.0010	0.092
February	− 0.367	− 0.0034	0.087
March	− 0.290	− 0.0035	0.084
April	− 0.329	− 0.0048	0.112
May	− 0.403	− 0.0045	0.061
June	− 0.758	− 0.0119	0.077
July	− 0.456	− 0.0080	0.068
August	− 0.721	− 0.0119	0.083
September	− 0.731	− 0.0148	0.079
October	− 0.342	− 0.0059	0.121
November	− 0.191	− 0.0042	0.147
December	− 0.663	− 0.0069	0.081
Mean	− 0.4427	− 0.00673	0.091

ently is affected to a greater extent by temperature than is the total solids content.

For the year 1946 there was an increase of 0.067 per cent in the total solids of the separated milk and an increase of 0.093 per cent fat in the whole milk for every 10° F. decrease in atmospheric temperature over a range from 34.8 to 78.8° F. in the Springfield, Missouri, area.

DISCUSSION

Since the fat test of all the milk received at this plant shows a definite negative correlation with the mean daily temperature, one may safely assume that the test of the milk of individual herds will show a similar change with temperature, and that the test of the milk from individual cows in each herd also will vary with the temperature. Actually, this has not been

TABLE 2

The relation between the mean daily fat in whole milk and the mean daily atmospheric temperature for 1946, calculated for monthly intervals

Month	Correlation coefficient	Regression coefficient	Deviation from regression
January	− 0.838	− 0.0105	0.091
February	− 0.673	− 0.0062	0.073
March	− 0.612	− 0.0058	0.068
April	− 0.629	− 0.0107	0.086
May	− 0.619	− 0.0060	0.060
June	− 0.757	− 0.0076	0.063
July	− 0.258	− 0.0036	0.039
August	− 0.770	− 0.0180	0.103
September	− 0.769	− 0.0183	0.094
October	− 0.742	− 0.0087	0.075
November	− 0.570	− 0.0085	0.095
December	− 0.642	− 0.0075	0.111
Mean	− 0.6566	− 0.00926	0.0798

found true in all cases, but it generally was found true during May and June, 1947, when a study was made of the fat test of the milk of 75 patrons.

The low correlation coefficient (–0.258) obtained for fat in July may be due to several factors. In July, 1946, the temperature was uniform for an extended period. Under this condition, the effect of the stage of lactation is likely to be more pronounced. Furthermore, in hot weather, cows may be shaded to a variable degree, which will have a variable effect on their body temperature. Finally, when the atmospheric temperature is uniform, the errors of sampling and testing are likely to affect the correlation coefficient to a greater degree.

Tracy and Tuckey (7) and others have reported data showing day-to-day changes in the fat test of individual patron's milk as received at milk plants. These results indicated that a majority of the samples tested vary throughout a 7-day test period from 0.3 to 0.75 per cent, and some samples vary over 2.5 per cent. Unpublished results of similar studies at this plant lead to the same conclusion. Although Tracy and Tuckey are inclined to attribute this variation to malpractice, it is probable that changes in air temperature largely are responsible.

The effect of air temperature should be recognized by dairymen and testing associations, who often judge the fat production of a cow on the basis of the results of a few days' testing. Obviously, these results may or may not reveal a true production record. Composite sampling or daily testing for several days is the most desirable way of arriving at reliable results.

The nonfat solids (as measured by the total solids in the separated milk) have not been of interest to the dairyman. However, in whole milk plants where standardization of the fat test is carried out, as in the case of cheese plants, the variation in the nonfat solids may have some significance, and the recognition of causes for this variation may be of value.

SUMMARY

The results of this study indicate that a definite relationship usually exists between the fat test of the whole milk received at the plant, the total solids of the separated milk, and the air temperature in the Springfield, Missouri, area.

The correlation coefficients between mean daily total solids of separated milk and mean daily temperature ranged from – 0.062 to – 0.758 and averaged – 0.443 for the year 1946, using monthly intervals.

The correlation coefficients between mean daily fat test of the whole milk as received and the mean daily temperature ranged from – 0.258 to – 0.838 and averaged – 0.657 for 1946.

There was an average increase of 0.067 per cent total solids of the separated milk for each 10° F. decrease in atmospheric temperature.

There was an average increase of 0.093 per cent fat in the whole milk for each 10° F. decrease in atmospheric temperature.

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FURTHER STUDIES OF THE PROCESSES INVOLVED IN THE PRESERVATION OF CAROTENE IN DEHYDRATED ALFALFA AND CEREAL GRASSES[1]

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In an earlier paper (1) it was pointed out, as also has been done by others, that a dehydrated alfalfa or cereal grass having a water content of 6–10 per cent lost carotene fairly rapidly under ordinary conditions of storage. After addition of water to a level of 15–20 per cent total and storage in waxed containers, these same products lost none of their carotene. In other words, under airtight storage and with the proper water content, the oxygen present gradually is used up and displaced by carbon dioxide. In the absence of oxygen, the carotene is preserved completely. As will be pointed out, these plant tissues with a water content of 6–10 per cent slowly respire, using up the oxygen and producing carbon dioxide, but the rate is so slow that carotene losses can occur before the oxygen present has been consumed completely. Higher water levels, such as 12–20 per cent, increase the rate of respiration, and the oxygen is used up much faster. When the product is stored in receptacles impervious to oxygen, conditions for carotene preservation readily are established.

To study the relation of water level to the rate of carbon dioxide production, new experiments were inaugurated. The type of drying to which the material was subjected also was studied.

EXPERIMENTAL

Two types of driers are employed extensively in this country for the preparation of commercial dehydrated alfalfa and cereal grasses. The one more commonly used appears to be the Arnold Drier (Heil) made by the Heil Company of Milwaukee, Wis. In this drier the furnace gases enter at a temperature of about 1850° F. (1010° C.) and leave the dehydrator at about 250° F. (121° C.). The product is in the drier from 1.5 to 5 minutes. The product produced is green in color, and grasses usually are brighter green than alfalfa, a phenomenon no doubt dependent upon the initial chlorophyll content. Quite surprising is the fact that the chlorophyll is retained at all, but it is more than probable that the organic structures of the plant materials never reach the temperature recorded for the ingoing and outgoing gases. (See sample 1 in table 1.)

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The second drier used is the Fulmer Drier. In this dehydrator a temperature of about 290° F. (143° C.) is used and the material is in the drying tunnel approximately 25 minutes. The time required for dehydration is dependent upon the initial moisture content and may be as much as 10 to 15 minutes longer when the material carries about 80 per cent water. This product also retains its green color (sample 2).

TABLE 1

Carbon dioxide production in dehydrated alfalfa and oat grasses

	Total water	CO_2	O_2
	(%)	(%)	(%)
Sample 1			
Alfalfa (Caple Bros.) Fulmer Drier. Entering gases 143° C., 30 min. Analyzed after 5 days' storage at room temperature. Original water 6%.	6.0	1.0	18.5
	10.0	2.0	17.1
	12.5	4.5	14.1
	15.0	7.0	11.6
	20.0	12.4	3.9
	25.0	17.9	0.0
Sample 2			
Alfalfa (Natl. Alfalfa Co.) Heil Drier. Entering gases 1010° C., 1.5 min. Analyzed after 5 days' storage at room temperature. Original water 9.4%.	10.0	4.4	14.4
	12.5	4.5	12.3
	15.0	8.0	6.9
	20.0	13.9	00.0
	25.0	14.3	00.0
Sample 3			
University alfalfa dried at 22° C. before fan and then dried in vacuum. Analyzed after 5 days' storage at room temperature. Original water 12.4%.	2.1	0.8	19.7
	5.0	0.9	19.1
	10.0	2.4	18.1
	15.0	7.2	12.6
	20.0	14.6	1.6
Sample 4			
Alfalfa (Cerophyl Co.) Heil Drier.* Analyzed after 5 days' storage at room temperature. Original water 7.2%.	10.8	3.9	14.4
	12.5	4.9	13.4
	15.0	7.6	10.5
	20.0	15.7	0.4
	25.0	18.7	00.0
Sample 5			
Oat grass (Cerophyl Co.) Heil Drier.* Analyzed after 5 days' storage at room temperature. Original water 10.1%.	10.0	3.5	16.3
	12.5	6.4	12.4
	15.0	10.2	5.9
	20.0	13.8	00.0
	25.0	14.8	00.0

* Carotene preservation complete (3 months' sealed storage) with 12 or 17 per cent total water.

Also used in these experiments was an alfalfa cut from a University field and dried before a fan at a temperature of 22–25° C. It then was dried in a vacuum to reduce the moisture content (sample 3).

Further studies were made on a dehydrated alfalfa (sample 4) and oat grass (Heil Drier, sample 5) in which the carotene was preserved completely when the products contained 12–17 per cent of water (alfalfa) and 15 per cent of water (oats) and were packed in flexo wax-covered receptacles and thus made airtight. These two materials gave most interesting data on the

rate of oxygen disappearance and carbon dioxide production necessary for complete carotene preservation.

All of the products described above were packed in glass tubes 200 mm. long and 35 mm. in diameter and provided with stopcocks and airtight seals at both ends. They were held at room temperature (22–25° C.) for 5 days; then the contained gases were sampled quantitatively for oxygen and carbon dioxide. The data secured on the five materials are shown in table 1.

In all of the materials, the carbon dioxide production rate was not greatly different (7–10 per cent) where the total water content was 15 per cent. This measurement was made at the end of a 5-day storage period. With 20 per cent total water and a 5-day storage period, the rate of carbon dioxide production was practically doubled (12–15 per cent). The faster rate of carbon dioxide production and oxygen utilization at a higher water level than 15 per cent does not necessarily mean that a more efficient carotene preservation in an airtight receptacle will be secured by the use of the higher water level. In sample 4 (alfalfa), carotene was preserved completely with 12 and 17 per cent of water, respectively, when packed in airtight receptacles for 3 months. In the case of sample 5 (oats), 15 per cent of total water preserved the carotene completely under similar storage conditions. The destruction of carotene is a gradual process, with the concentration of oxygen a possible factor, but one not yet studied. The destruction of chlorophyll is associated with the high water levels and rapid carbon dioxide production. With 15 per cent of total water the original green color is retained much more effectively than when 20 per cent of total water is used. Since 12–15 per cent of total water in an airtight receptacle completely preserves the carotene, it appears that a commercially acceptable product in respect to both color and carotene readily can be prepared, provided an economical airtight receptacle becomes available.

To determine the influence of both time and water content on carbon dioxide production and oxygen consumption, a dehydrated alfalfa prepared by the Fulmer process and one prepared by the Heil dehydrator were put up in glass tubes with 10, 12.5, 15, 17.5, 20, and 25 per cent of total water. The gases in the tubes were analyzed at the end of 5, 10, 15, 20, 25, and 30 days. The tubes were held at room temperatures of 22–25° C. It also should be pointed out that when the total water content of both these alfalfas was 12.5 per cent, the carotene was preserved completely and the green color well retained when stored in waxed receptacles for 3 months at room temperature. With 10 per cent or less total water, the carotene loss under sealed conditions is variable and unpredictable. Dehydrated oats, rye, and alfalfa have shown carotene losses in 3 months of from 0.6 to 31 per cent. Most of the losses varied from 5–20 per cent. The results on the influence of time and water level on gas production and oxygen consumption are given in table 2.

TABLE 2

Rate of carbon dioxide production and oxygen consumption as influenced by level of water and time of storage

Storage time (days)	10% total water		12.5% total water		15% total water		17.5% total water		20% total water		25% total water	
	CO_2	O_2	CO_2	O_2	CO_2	O_2	CO_2	O_2	CO_2	O_2	CO_2	O_2
	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Alfalfa* (Natl. Alfalfa Co.) Heil Drier, storage at 22–25° C.												
5	4.8	12.2	4.9	12.6	7.5	7.7	11.6	2.5	13.9	0.0	14.3	0.0
10	6.3	8.6	8.2	5.5	10.5	2.9	14.3	0.0	.....	.....	.....	.....
15	8.0	5.7	10.5	2.1	11.8	0.3	.....	.....	.....	.....	.....	.....
20	8.7	4.1	10.5	1.5	13.0	0.0	.....	.....	.....	.....	.....	.....
25	10.9	0.6	14.8	0.08	.....	.....	.....	.....	.....	.....	.....	.....
30	11.0	0.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Alfalfa* (Caple Bros.) Fulmer Drier, storage at 22–25° C.												
5	2.4	16.8	4.5	14.3	7.6	11.2	12.6	4.9	16.1	1.2	17.9	0.0
10	3.8	14.0	7.7	10.5	12.5	4.4	17.2	0.8	20.1	0.0	.....	.....
15	7.5	12.7	8.3	9.1	11.6	5.0	18.2	0.0	.....	.....	.....	.....
20	6.2	10.6	10.4	5.8	14.8	1.7	.....	.....	.....	.....	.....	.....
25	5.0	10.3	12.6	2.6	14.7	1.0	.....	.....	.....	.....	.....	.....
30	6.6	8.3	13.3	1.8	15.0	0.4	.....	.....	.....	.....	.....	.....

* Complete carotene preservation with 12.5% water and sealed storage at room temperature for 3 months.

It is clear from the data that carbon dioxide production and oxygen utilization definitely are related to both time of storage and the water levels. With 10 per cent of total water the rate of carbon dioxide production was distinctly reduced in the two materials examined. After 20 days of storage 4.1 per cent of oxygen still remained in the Heil dehydrated product and 10.6 per cent in the Fulmer dehydrated alfalfa. With 12.5 per cent of water and the same time of storage, the oxygen was reduced to 1.5 per cent in the first product and to 5.8 per cent in the second product. There was complete carotene preservation under sealed conditions with 12.5 per cent of total water in both materials on storage for 3 months at room temperature. Apparently reduced oxygen tension is an important factor in carotene preservation but to an extent as yet undetermined.

As the total water was increased, the reactions were more rapid. With 20 per cent of total water, the oxygen was consumed completely in 5 days

TABLE 3

Effect of temperature on carbon dioxide production and oxygen consumption in dehydrated alfalfa with 15% of total water (analysis at end of storage for 5 days)

Temperature	CO_2	O_2
	(%)	(%)
− 6° C.	1.4	19.7
+ 5° C.	2.0	18.2
+ 24° C.	8.0	10.5
+ 37° C.	19.4	0.8

with the Heil dehydrated alfalfa and 1.2 per cent remained in the Fulmer product. In 10 days the oxygen was consumed completely in the Fulmer material.

In addition to the factors of time and water level on the extent of carbon dioxide production and oxygen consumption, the factor of temperature was investigated. Using the usual procedure, a dehydrated alfalfa was set up in glass tubes and stored for 5 days at varying temperatures with 15 per cent of total water. The results are given in table 3. As expected, the speed of the reaction was influenced markedly by the temperature as well as by the water level and time of storage. There was a fairly close agreement between the two alfalfas produced by the different drying processes in respect to rates of carbon dioxide production with variable water content. The longer exposure to a lower heat, as in the Fulmer process, still preserved the respiratory enzymes, with the rate of carbon dioxide production at a given water level only slightly lower.

Probably the differences in respiratory action of alfalfas dried by different processes are due only partially to the temperatures and time of drying. The stage of growth of the plant may be important.

SUMMARY

1. The rate of carbon dioxide production and oxygen consumption by dehydrated alfalfa and cereal grasses under sealed conditions was studied at moisture levels of 10–25 per cent. The rate of respiration increased as the level of moisture and the temperature were increased. The extent of carbon dioxide production and oxygen consumption was variable with time at a given moisture level.

2. The rate of carbon dioxide production in a dehydrated alfalfa with 10 per cent of total water is less than one-third the rate observed when the product contains 20 per cent of total water.

3. With 10 per cent or less of total water, the rate of carbon dioxide production and oxygen consumption generally is too slow to insure complete carotene preservation under sealed conditions. The carotene losses may vary from 5–30 per cent during storage at room temperatures of 22–25° C. for 3 months. With 12.5 per cent of total water under sealed conditions for 3 months, both products (alfalfa, Heil Drier, and alfalfa, Fulmer Drier) retained completely their carotene content as well as their green color.

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DEHYDRATED SWEET POTATOES—THEIR FEEDING VALUE AND DIGESTIBILITY

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Dehydrated sweet potatoes are being used more and more in the southern states as a carbohydrate feed for livestock. This has come about because of the increased acreage planted in sweet potatoes and the increase in the number of dehydrating plants. Although corn is the chief carbohydrate feed used, much of it has to be brought into the southern states since many areas cannot produce an adequate supply locally. The 1946 statistics (17) show that the 120,000 acres of sweet potatoes planted in Louisiana produced 10,824,000 bushels, of which approximately 13 per cent were dehydrated. At present there are 67 dehydrating plants in the state, 50 of which are used exclusively for dehydrating sweet potatoes (18). Most of the potatoes dehydrated are now sold as feed for livestock, and a smaller amount is being used as human food. The reverse was true during the war years.

LITERATURE REVIEW

Investigators in Tennessee (6, 11), Alabama (8, 9), Mississippi (3), South Carolina (7), and Oklahoma (4, 5) have made studies of the feeding value of dried sweet potato meal in finishing and fattening steer calves and hogs and as a substitute for corn in rations of beef cattle, mules, and hogs. In general, dried sweet potatoes were found to be worth approximately 90 to 95 per cent as much as corn for fattening beef cattle. Mules and hogs did not relish dried sweet potatoes but tolerated the meal to the best advantage when it replaced not more than 50 per cent of the corn in the ration.

Copeland (2) of Texas, in comparing dehydrated sweet potato meal and ground shelled corn for lactating cows, reported 0.79 lb. or 3 per cent more milk per cow daily in favor of corn. Thus, the dried sweet potato meal was 90 per cent as valuable as corn for milk production. Butter produced from cows on the sweet potato meal contained 37.98 I.U. of vitamin A per gram compared with 31.11 I.U. from butter produced by cows fed yellow corn.

Briggs *et al.* (1) of the Oklahoma Station recently reported on the digestibility of dried sweet potatoes by steers and lambs. Alfalfa or prairie hay and cottonseed meal were used as basal feeds, and tests on the digestibility of ground yellow corn also were run for comparative purposes. On the dry matter basis the average T.D.N. value of the dried sweet potatoes for steers was 86.05, as compared to 85.80 for the corn.

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EXPERIMENTAL

Feeding Trials

In 1943, sun-dried sweet potato meal made from a high-starch sweet potato variety, L–45, was fed in comparison with ground yellow corn meal to 16 Holstein and 4 Jersey milking cows. The double reversal experimental design (16) was used. This design compared two roughages and also two concentrate mixtures in the same feeding trial, utilizing the analysis of variance. The concentrate ration consisted of three parts of dehydrated sweet potato meal or corn meal and one part of cottonseed meal. One per cent each of salt, steamed bonemeal, and oyster shell flour were added. The mixtures were fed to the cows at the rate of 9 lb. per pound butterfat produced. In addition, each cow received approximately 30 lb. of corn silage and 17 lb. of either lespedeza or alyce clover hay daily. Daily 4 per cent fat-corrected milk yields and butterfat yields favored the yellow corn meal by 4.19 and 4.55 per cent, respectively. This trial indicated that the dehydrated sweet potato meal was equal to approximately 88 per cent corn.

In 1944 a second feeding trial was conducted with 16 Holsteins and 4 Jerseys, using a commercial dehydrated sweet potato meal of the Porto Rico variety. In this trial ground snapped corn (including cob and shuck), rather than corn meal, was compared to dehydrated sweet potatoes. Adjustment to equalize nutrient intake was made for the extra bulk caused by the cob and shuck by adding 20 per cent more of the ground snapped corn. The amount of grain mixture fed was established during the 2-week preliminary period using the recommended nutrient requirements as set forth by Morrison (12). Corn silage and lespedeza hay or alyce clover hay also were fed, as in the first trial. Milk production for the cows on the dehydrated sweet potatoes was 24.9 lb. per cow daily, as compared with 25 lb. for the cows on the ground corn. One pound of dehydrated sweet potato meal was equal to approximately 1.2 lb. of ground snapped corn (including cob and shuck). Vitamin A analyses of the butterfat from milk produced by cows on sweet potatoes were 19 per cent higher than on butterfat produced by cows on ground corn. The values were 43 I.U./g. and 35 I.U./g., respectively.

In 1946 a commercial dehydrated sweet potato meal produced by utilizing cull potatoes, peelings, bruised sections of potatoes, and similar material was used in a palatability study. This meal was darker in color than the previous products. It is now known that cut or spoiled potatoes turn dark upon dehydration. This product was not very palatable—many of the animals went off feed at various times. When a good quality product of dehydrated sweet potatoes produced from whole tubers was fed, normal amounts were eaten.

Digestion Trials

Four dairy steers weighing from 400 to 500 lb. each were used as experimental animals. The procedure used in the management of the animals and procuring the feed samples and excreta was the same as that reported in an earlier paper (13). In general, it included the use of at least a 10-day preliminary period and a 10-day collection period. The feces were collected in a canvas collection bag. A 1/50 aliquot was taken from each day's fecal output for each steer and stored in a refrigerator at 0° C. until completion of the collection period. Nitrogen determinations were made on aliquots of the fresh excreta, while dried excreta samples were used for the other analyses.

The basal feeds used were common lespedeza hay, alyce clover hay, or Kobe lespedeza hay and cottonseed meal. Digestion coefficients (13, 14, 15) were determined for these feeds prior to each sweet potato digestion trial.

Trial I was made on a 1945 commercial dehydrated sweet potato meal

TABLE 1

Analyses of the basic feeds fed in the digestion trials (dry basis)

Trial	Feed	Dry matter	Crude protein	Crude fat	Crude fiber	N.F.E.
		(%)	(%)	(%)	(%)	(%)
I	Common lespedeza hay	89.30	10.52	2.06	35.70	44.75
II	Alyce clover hay	92.14	13.22	1.45	38.62	40.09
III	Alyce clover hay	91.55	12.77	1.71	39.50	39.31
IV	Kobe lespedeza hay	87.80	11.53	1.94	39.92	40.77
	Cottonseed meal	91.53	44.73	6.99	10.19	30.33

(Porto Rico variety), using common lespedeza hay as a basal feed. Four to five pounds of dehydrated sweet potato meal were fed to each steer and replaced an equivalent amount of hay on the digestible protein and T.D.N. basis in the basal ration. The amount of hay was adjusted so that the animals maintained their weights during the preliminary period, after which the digestion trial was begun. Trial II made use of alyce clover hay and a 1946 commercial dehydrated sweet potato meal; trial III, of alyce clover hay and a 1946 commercial dehydrated sweet potato meal made from cull and sectioned potatoes; trial IV, of Kobe lespedeza hay and cottonseed meal and a 1947 commercial dehydrated sweet potato meal. Table 1 presents the compositions of the basal feeds on the dry basis.

The compositions, average apparent coefficients of digestibility, and total digestible nutrients of the dehydrated sweet potatoes on the dry basis for the various trials are presented in table 2.

DISCUSSION

The apparent variations and non-digestibility of the protein, fat and fiber of the dehydrated sweet potatoes, as seen in table 2, might be explained

by the small proportion of the total intake of these constituents in the ration. The apparent non-digestibility of the crude protein may be due to several factors, namely: (a) heating of the protein during the drying process, which could tend to make it less digestible, (b) the presence of non-protein nitrogen compounds that are not digestible, or (c) an apparent "depression of digestibility" as observed by Holdaway *et al.* (10) when a high carbohydrate feed such as apple pomace was added to a basal ration low in protein. In digestion trials with steers, Briggs *et al.* (1) obtained an apparent digestibility of crude protein in their sun-dried sweet potatoes amounting to 42.7 ± 8.36 per cent and 59.0 ± 7.3 per cent with prairie hay and cottonseed meal, and alfalfa, respectively. Their sun-dried sweet potatoes

TABLE 2

The composition, average apparent digestion coefficients, and total digestible nutrients of commercial dehydrated sweet potatoes (dry basis)

Trial	Year of manufacture	Dry matter	Protein	Fat	Fiber	N.F.E.	
		(%)	(%)	(%)	(%)	(%)	
I	1945	92.70	5.39	0.91	4.21	86.28	.....
II	1946	92.96	5.04	1.47	1.67	88.63	.....
III	1946†	90.40	5.04	0.55	4.78	85.99	.....
IV	1947	85.35	4.17	1.15	4.46	84.88	.....
			Average apparent digestion coefficients				T.D.N.
I	1945	.....	16.71	.....	.....	94.46	81.06
II	1946	.....	−24.74	49.07	.....	84.53	76.38
III	1946*†	.....	−52.36	.....	.....	83.47	71.78
IV	1947	.....	−40.29	94.17	.....	88.23	79.31

* Analyses based on three steers only; product, made from cull and sectioned potatoes, was slightly unpalatable, one of the steers refusing to eat his quota.
† Poor quality.

were higher in composition of crude protein, 7.15 per cent, than the values of 4.17 to 5.39 per cent reported in this paper. However, these investigators also experienced considerable difficulty in obtaining the apparent digestibility of the fat and fiber from their sun-dried sweet potatoes; the apparent digestibility of crude fiber seemed to be enhanced by the basic feed of alfalfa hay. Their T.D.N. values for sweet potatoes when fed to steers were 81.7 with prairie hay and cottonseed meal as the basal feed and 91.4 with alfalfa hay as the basal feed.

In this study the coefficients of digestibility for the N.F.E. were consistent. As this constituent made up over 84 per cent of the dry matter in the dehydrated sweet potato, the apparent lack of digestibility of the other constituents had but small effect on the T.D.N. content. The low content of protein precludes this product from being an important source of this nutrient. The T.D.N. values for commercial dehydrated sweet potatoes

ranged from 76 to 81 per cent on the dry basis; the poor quality commercial dehydrated sweet potatoes made from culled potatoes, peelings, and bruised sections of potatoes contained 71 per cent T.D.N.

SUMMARY

1. Dehydrated sweet potatoes made from whole tubers were palatable, while a poor quality product made from culled, bruised, and sectioned potatoes was slightly unpalatable.

2. Feeding trials have shown that dehydrated sweet potatoes have approximately 88 per cent the value of yellow corn meal, and are approximately 17 per cent more valuable than ground snapped corn, including cob and shuck, for milk production.

3. Digestion trials have shown that good quality dehydrated sweet potatoes contained from 76 to 81 per cent T.D.N., while a poor quality product contained 71 per cent T.D.N. on the dry basis.

4. Dehydrated sweet potatoes are of value in the dairy ration, not only because of the high digestibility of their carbohydrate, but also because of their high carotene content, which increases the vitamin A value of the butterfat.

ACKNOWLEDGMENTS

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GRASS AND LEGUME SILAGE STUDIES USING 2-QUART GLASS JARS AS MINIATURE SILOS[1,2]

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The present emphasis on grassland farming and the recognition of grass silage as a practical feed have raised many questions regarding methods of preservation, losses that occur in the silo and investigational technics for silage studies. Workers at the Pennsylvania Station (12) have made extensive studies of bacteriological and chemical changes in grass silage put up with various preservatives. The silages used in these investigations were stored in small wooden silos 5 feet in diameter and 20 feet high. While these small silos adapted themselves much better to sampling than would larger commercial structures, the job of procuring representative samples at different intervals after ensiling presented a difficult problem.

Studies have been made using glass jars and even milk bottles as miniature silos (2, 4, 9), and results have shown that silage preserved in this manner was similar in composition and appearance to that stored in conventional silos.

To study further the practicability of using 2-quart glass jars as silos, and to study fermentation changes under different treatments, an experiment was designed in the spring of 1946.

EXPERIMENTAL PROCEDURE

The silages used in this experiment were: A, alfalfa; B, brome grass-Ladino clover; C, orchard grass-Ladino clover. Each was studied under the following treatments:

1—Unwilted, no preservative.
2—Unwilted, plus 60 lb. of molasses per ton of green material.
3—Unwilted, plus 100 lb. of hominy feed per ton of green material.
4—Unwilted, plus 300 lb. of wheat straw per ton of green material.
5—Wilted, no preservative.
6—Wilted, plus 60 lb. of molasses per ton of green material.
7—Wilted, plus 100 lb. of hominy feed per ton of green material.

The silages hereinafter will be designated according to the above numbers and letters. For example, A–1 is alfalfa, unwilted, with no preservative added.

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The material to be ensiled was chopped with a Fox ensilage cutter set to cut 0.25-inch lengths. In the case of treatments 1 through 4, the material was prepared with the proper amount of preservative and ensiled as quickly as possible after cutting. In treatments 5 through 7, the crop was wilted to approximately 65 per cent moisture before ensiling. Each treatment was replicated ten times in glass jars of 2-quart capacity. It was estimated that one such jar would provide an adequate sample for each analysis, the analyses to be made at intervals of 1, 7, 14, 30, 60, and 170 days from the ensiling date. The silage was packed thoroughly; the jars were sealed with rubber jar rings and paraffin wax and stored at 60 to 70° F.

Samples were examined at the intervals named above, and the following measurements and observations were made:

(a) Odor and apparent quality of the ensiled material.

(b) pH of the silage extract. This determination was made with a Beckman pH meter.

(c) Dry matter. Moisture was removed from samples by oven-drying at 95° C.

(d) Sugar. The silage extract was prepared and treated according to the method used by McAuliffe (6), and sugar determinations were made using the method of Stiles *et al.* (11).

(e) Nitrogen. Analyses were made on samples of all the silages at intervals of 1 and 60 days following ensiling.

(f) Carotene. The silages in B and C groups were analyzed for carotene content at intervals of 1, 7, 14, and 30 days after the ensiling date. The method of Moore and Ely (7) was used in these determinations.

Group A was ensiled about 2 months later than the other two; hence, in most of the data reported here, it will be considered separately from groups B and C. Lactic acid determinations were made on the alfalfa silages, samples being taken at intervals of 1, 3, 5, 7, 10, 14, 30, 60, and 110 days from the ensiling date. The lactic acid method used was a modification of that of Barker and Summerson (1).

RESULTS AND DISCUSSION

Table 1 shows the dry matter content of the silages studied in this experiment, and table 2 gives an analysis of variance of these dry matter values. In this analysis, differences among treatments were highly significant. This was expected, since in three cases the silages were wilted. Although differences among the means of the various sampling intervals were noticeable, there was no consistent increase or decrease in moisture content from the date of ensiling to 60 days later. This is not surprising, as there was no chance for a loss of moisture due to seepage, which might have occurred in a conventional silo.

TABLE 1

Per cent dry matter of 14 different silages as estimated at various sampling intervals

Group	Interval from ensiling date (Days)	Treatments							
		1	2	3	4	5	6	7	Mean
B	1	29.59	30.53	31.63	38.97	40.86	42.31	43.27	36.74
	7	28.77	29.76	30.44	36.92	40.19	40.98	41.51	35.51
	14	29.22	29.15	30.84	36.62	39.29	38.20	41.80	35.02
	30	28.27	29.24	30.48	38.48	39.69	41.26	42.83	35.75
	60	29.64	30.09	29.53	37.15	39.99	41.04	41.93	35.62
	Mean	29.10	29.75	30.58	37.63	40.00	40.76	42.27	35.73
C	1	23.60	23.37	24.44	30.00	31.95	32.70	34.00	28.58
	7	24.49	25.04	26.23	31.47	33.16	32.27	34.06	29.53
	14	22.47	23.72	25.89	29.84	32.43	31.36	33.71	28.49
	30	21.01	21.30	24.49	29.72	31.12	31.57	33.51	27.53
	60	22.37	23.52	24.18	29.56	31.31	31.54	33.04	27.93
	Mean	22.79	23.39	25.05	30.12	31.99	31.89	33.66	28.41

The most striking fact revealed by this analysis is the small standard deviation. In group B the mean and standard deviation were 35.73 ± 0.677, the coefficient of variation being 1.88 per cent. In group C, corresponding values were 28.41 ± 0.608 and 2.14 per cent, respectively. Analysis of B

TABLE 2

*Analysis of variance of dry matter content of 14 different silages at various sampling intervals**

Source of variance	Degrees of freedom	Sums of squares	Mean squares
	B		
Total	34	1002.61	.....
Treatment	6	960.47	163.41†
Interval	4	11.06	2.77†
Error	24	11.08	0.46
Mean = 35.73.			
Standard deviation = 0.677.			
Coefficient of variation = 1.88%.			
	C		
Total	34	642.85	.....
Treatment	6	617.93	102.99†
Interval	4	16.05	4.01†
Error	24	8.87	0.37
Mean = 28.41.			
Standard deviation = 0.608.			
Coefficient of variation = 2.14%.			

* Treatment 4 was omitted from the analysis in order that uniform comparisons could be made of the wilted and unwilted silages.

† Highly significant.

and C together, and including treatment 4, gives a general mean and standard deviation of 32.07 ± 1.00. The coefficient of variation in this case is 3.12 per cent. Such small standard deviations indicate that sampling variation, normally high in silage experiments, can be kept to a negligible minimum in carefully controlled experiments using fruit jars as miniature silos. It is suggested by Snedecor (10) that a 5 per cent coefficient of variation is an excellent value in a well controlled field crop experiment.

It generally is recognized that a measure of the pH of a silage provides a

TABLE 3

pH values of 21 silages at different intervals

Group	Interval from ensiling date (Days)	Treatments							
		1	2	3	4	5	6	7	Mean
B	1	4.70	4.53	4.59	4.88	4.98	4.87	4.91	4.78
	7	4.02	3.92	3.93	4.37	4.18	4.15	4.12	4.10
	14	4.06	4.03	4.05	4.50	4.39	4.19	4.16	4.20
	30	4.09	4.01	3.99	4.31	4.09	4.09	4.09	4.10
	60	3.98	3.81	3.99	4.18	4.02	4.01	3.99	4.00
	170	3.99	3.95	4.00	4.33	4.13	4.13	4.08	4.09
	Mean	4.14	4.04	4.09	4.43	4.30	4.24	4.23	4.17
C	1	4.92	4.78	4.72	5.01	5.19	4.94	5.02	4.94
	7	4.20	4.03	4.05	4.39	4.50	4.45	4.45	4.30
	14	4.10	4.09	4.09	4.32	4.44	4.30	4.39	4.25
	30	4.08	3.98	3.93	4.21	4.27	4.18	4.14	4.11
	60	4.07	4.00	3.97	4.18	4.25	4.16	4.15	4.11
	170	4.21	4.01	4.08	4.18	4.19	4.11	4.12	4.13
	Mean	4.26	4.15	4.14	4.38	4.47	4.36	4.38	4.29
A	1	5.04	4.71	5.98	5.68	5.41	5.22	5.39	5.35
	3	4.68	*	4.42	4.87	4.87	4.53	4.80	4.70
	5	4.66	4.28	4.39	4.78	4.78	4.32	4.67	4.55
	7	4.61	*	4.36	4.76	4.78	4.28	4.59	4.56
	10	4.55	*	4.29	4.68	4.78	4.28	4.58	4.53
	14	4.51	4.10	4.20	4.59	4.76	4.19	4.52	4.41
	30	4.48	*	4.25	4.66	4.70	4.19	4.43	4.45
	60	5.19	*	4.18	4.73	4.63	4.21	4.41	4.56
	110	4.58	*	4.12	4.79	4.62	4.08	4.30	4.42
	Mean	4.70	4.36	4.47	4.84	4.81	4.37	4.63	4.62

* Missing values due to loss of samples in storage.

very good indication of silage quality. In this experiment, therefore, a careful record was made of pH values at various intervals. Table 3 shows the pH values of all the silages studied in this experiment. The analysis of variance of groups B and C is found in table 4.

The most marked differences to occur were among intervals. This was to be expected, since it is established that in the fermentation of most silages some time is required for maximum acidity to develop. The difference between groups also was highly significant. The lower moisture content of the silages in group B may have had a bearing in this connection.

Among treatments within both the wilted and unwilted groups, the differences were highly significant. In two cases the molasses-treated silages had the lowest pH values and in two cases the hominy-treated silages were lowest; but in all cases the untreated silages were high. The difference between wilted and unwilted silages, irrespective of variation among treatments, was highly significant, the mean pH of the former being 4.14 and that of the latter 4.33. Corresponding values for silages tested after 60 days from the ensiling date were 4.01 and 4.11, respectively. The discrepancy between these two pairs of values may be explained by the highly significant interaction between interval variance and the variance between unwilted

TABLE 4

*Analysis of variance of pH values**

Source of variation	Degrees of freedom	Sums of squares	Mean squares
Total	71	7.0079	.....
Treatments:			
Within unwilted	2	0.0767	0.0384†
Within wilted	2	0.0590	0.0295†
Between unwilted & wilted	1	0.6574	0.6574†
Groups	1	0.2616	0.2616†
Intervals	5	5.6152	1.1230†
Int. × group	5	0.0711	0.0142†
Int. × (between unw. & w.)	5	0.1124	0.0225†
Int. × within unw.	10	0.0234	0.0023
Int. × within w.	10	0.0236	0.0024
Group × (between unw. & w.)	1	0.0139	0.0139
Group × within unw.	2	0.0093	0.0047
Group × within w.	2	0.0052	0.0026
Int. × group × (between unw. & w.)	5	0.0470	0.0094
Int. × group × within unw.	10	0.0154	0.0015
Int. × group × within w.	10	0.0167	0.0017

* Analysis made only on groups B and C, and treatment 4 was omitted.
† Significant at the 1% level.

Standard deviation = 0.075.
General mean = 4.233 ± 0.075.
Coefficient of variation = 1.77%.

and wilted silages. This discrepancy indicates that the fermentation in the wilted silages proceeded at a somewhat slower rate than in the unwilted group. Even after 170 days, some of the silages which had been wilted still were increasing in acidity. This characteristic of slow fermentation was most noticeable in the alfalfa group (see table 3, group A).

The general mean and standard deviation for the pH values of groups B and C were 4.233 ± 0.075, the coefficient of variation being 1.77 per cent. This low coefficient of variation corroborates a previous observation that sampling variation in this experiment has been kept to a minimum.

Examination of the data reported on extensive grass silage experiments

at the Pennsylvania Station (6) revealed a pronounced inverse relationship between the pH value and sugar content of grass silage. A rather marked direct correlation also was found between the reducing substances and lactic acid content of the grass silages studied in these trials. Appreciable quantities of both reducing substances and lactic acid were associated with high-quality grass silage. Therefore, it was deemed advisable to make sugar determinations at various intervals on the silages reported herein. Table 5 contains a summary of the values derived from these determinations, and table 6 shows the analysis of variance.

The analysis in table 6 shows a highly significant variation among treatments within both the wilted and unwilted silages. In all cases except one,

TABLE 5

Glucose content of 14 silages at various sampling intervals
(Milligrams per gram of silage—dry basis)

Groups	Interval from ensiling date (Days)	Treatments							
		1	2	3	4	5	6	7	Mean
B	1	3.81	9.14	3.63	1.73	1.63	11.97	9.96	5.98
	7	12.99	22.15	7.68	8.24	16.43	16.19	15.07	14.11
	14	4.47	9.31	5.20	7.87	11.48	15.26	11.85	9.35
	30	5.64	10.79	6.64	8.69	12.28	15.68	14.27	10.57
	60	6.32	18.59	8.27	9.81	12.90	15.65	13.96	12.21
	170	6.29	14.55	11.87	10.82	11.90	14.55	14.08	12.01
	Mean	6.59	14.09	7.22	7.86	11.10	14.88	13.20	.....
C	1	2.37	11.37	2.00	1.36	1.88	5.14	3.12	3.89
	7	2.76	14.02	5.11	3.62	4.78	14.24	4.55	7.01
	14	2.24	7.57	5.27	3.55	5.44	9.75	4.13	5.42
	30	1.62	7.82	5.67	5.61	6.06	14.08	3.48	6.33
	60	4.96	7.44	8.42	6.11	8.38	15.21	6.89	8.20
	170	2.50	5.73	7.31	5.18	7.91	14.64	9.30	7.51
	Mean	2.74	8.99	5.63	4.24	5.74	12.18	5.25	.....

the sugar content of the molasses-treated silage was highest; that of the hominy-treated silage was intermediate, and those of silages receiving no preservative were lowest. There also were marked differences between the wilted and unwilted silages, the wilted silages containing 40 per cent and 33 per cent more sugar than the unwilted samples in groups B and C, respectively. The difference between intervals also proved to be highly significant. The table likewise shows a noticeable interaction between groups and treatments, within the wilted silages. Although this interaction is barely significant, it indicates that the effects of treatment on wilted silage in group B were different from those in group C. In the latter group, treatment 5 showed to a better advantage than treatment 7. This interaction further suggests that the moisture content of the wilted silage in C is more conducive to desirable fermentation than that in B (see table 1).

Silage samples from group A were analyzed for lactic acid content at various intervals. The results of this study are recorded in table 7. Analysis of variance illustrates that differences among treatments were highly significant. Although the means of the unwilted silages are high in this comparison, the wilted samples had undergone the most consistent increase in lactic acid content and the quality of the wilted silages apparently was superior to that of the unwilted silages in later stages of the experiment. The silage prepared with 300 lb. of wheat straw per ton developed decidedly less lactic acid than those under any other treatment. Differences among intervals were large but quite variable.

TABLE 6

*Analysis of variance of glucose content of 14 different silages at various sampling intervals**

Source of variation	Degrees of freedom	Sums of squares	Mean squares
Total	71	1665.893	.....
Treatments:			
Within unwilted	2	306.231	153.116†
Within wilted	2	181.148	90.574†
Between unwilted & wilted	1	146.120	146.120†
Groups	1	352.407	352.407†
Intervals	5	278.046	55.609†
Int. × group	5	42.490	8.498
Int. × (between unw. & w.)	5	47.391	9.478
Int. × within unw.	10	81.660	8.166
Int. × within w.	10	26.636	2.636
Group × (between unw. & w.)	1	15.097	15.097
Group × within unw.	2	19.005	8.503
Group × within w.	2	41.294	20.647‡
Int. × group × (between unw. & w.)	5	34.093	6.819
Int. × group × within unw.	10	50.240	5.024
Int. × group × within w.	10	44.034	4.403

* Analysis does not include treatment 4.
† Significant at the 1% level.
‡ Significant at the 5% level.

Standard deviation = 2.588.
General mean = 8.967 ± 2.588.

Samples of the silages in all three groups were taken for crude protein analysis at intervals of 1 and 60 days after ensiling. The protein content of the different silages is shown in table 8. The analysis of variance shows a highly significant treatment effect, which is due to the lower protein values in treatment 4. When this treatment is omitted from the analysis, treatment effects are not significant.

The most pronounced effects occurred between groups, because of the much higher protein content of the silage in A, the alfalfa group. There was a highly significant difference between intervals in this analysis. In every case except two, the protein content of silage sampled on the first day

was higher than that sampled 60 days after ensiling. The average decrease from 1 to 60 days was 4.90 per cent. It is difficult to explain this loss in nitrogen but probably it was due to ammonia, formed during fermentation, which was lost during sampling.

There was a noticeable interaction between treatment and groups, but this effect was not significant when the straw-treated silages were omitted, and the interaction probably has no practical importance.

A comparison was made of treatments 1 and 3, which were unwilted, with 5 and 7, which were the corresponding treatments in the wilted group.

TABLE 7

Micrograms of lactic acid per gram of silage in group A (Dry basis)

Interval from ensiling date (Days)	Treatments*						
	1	3	4	5	6	7	Mean
1	13.38	2.71	7.23	14.44	19.02	7.66	10.74
3	44.75	51.41	29.01	27.79	33.42	29.80	36.03
5	34.54	38.55	24.85	27.29	37.54	30.24	32.17
7	37.53	42.65	26.74	29.30	40.64	34.48	35.22
10	27.08	29.52	19.48	28.38	39.60	30.00	29.01
14	65.16	54.88	37.17	36.41	43.73	39.72	46.18
30	60.76	57.09	33.69	39.14	44.14	38.71	45.59
60	37.68	58.67	32.53	39.35	42.08	39.72	41.67
110	41.38	49.21	22.21	34.32	45.59	36.70	38.24
Mean	40.25	42.74	25.88	30.71	38.42	31.89	34.98

Analysis of variance

Source of variation	Degrees of freedom	Sums of squares	Mean squares
Total	53	8878.57	
Treatment	5	1893.97	378.79†
Interval	8	5553.59	694.20†
Error	40	1431.01	35.78

* Treatment 2 has been omitted because of the loss of a number of samples in storage.
† Significant at the 1% level.

Standard deviation = 5.98.
Mean = 34.98 ± 5.98.

The wilted silage contained an average of 2.26 per cent less protein than the unwilted silage. Table 9 shows the effect of the seven treatments on carotene content of the ensiled crops.

Excluding treatment 4, in which carotene values were low chiefly because of the straw content, the wilted silages contained 30 per cent and 37 per cent less carotene than the unwilted crops in groups B and C, respectively. Although the carotene values reported in table 9 are quite variable, there was an apparent increase in carotene content of the silages from the date of ensiling to 30 days later. In only two cases were decreases noted.

These results confirm those obtained at other stations (3, 5, 8), where it was found that the carotene content in silage was higher than in the original green forage.

The quantities of silage used in these studies precluded the possibility of making palatability tests or running feeding trials; but a careful record was kept of the odor and apparent quality of the various silages at different

TABLE 8

Percentage of crude protein (dry matter basis) in 18 silages at 1 day and 60 days after ensiling

Groups	Interval from ensiling date (Days)	Treatments*						
		1	3	4	5	6	7	Mean
A	1	17.06	16.19	12.50	15.94	16.63	16.19	15.75
	60	16.25	15.88	11.56	16.00	15.50	16.38	15.26
	Mean	16.66	16.04	12.03	15.97	16.07	16.29	15.51
B	1	11.94	11.75	8.25	10.19	11.19	10.63	10.66
	60	10.44	10.94	8.00	9.50	10.19	10.06	9.86
	Mean	11.19	11.35	8.13	9.85	10.69	10.35	10.26
C	1	11.00	11.50	9.13	11.38	10.81	11.63	19.91
	60	10.00	10.81	8.50	11.31	10.69	11.00	10.39
	Mean	10.50	11.16	8.82	11.35	10.75	11.32	10.65

Analysis of variance

Source of variation	Degrees of freedom	Sums of squares	Mean squares
Total	35	263.0660	
Treatments	5	45.1541	9.0308†
Groups	2	205.3368	102.6684†
Intervals	1	3.3003	3.3003†
Treat. × group	10	7.5695	0.7570†
Treat. × int.	5	0.7193	0.1439
Group × int.	2	0.1777	0.0889
Treat. × group × int.	10	0.8083	0.0808

* Treatment 2 omitted because of missing data.
Mean decrease in protein from 0 to 60 days: A = 3.11%; B = 7.50%; C = 4.77%.
† Significant at the 1% level.

Standard deviation = 0.586.
General mean = 12.14 ± 0.586.
Coefficient of variation = 4.83%.

intervals. In general those silages with pH values of less than 4.2 were of desirable quality and well preserved. The unwilted silages in groups A and C, irrespective of treatment, were, in the later stages of fermentation, inferior to the wilted silages in the same groups. In group B this was not true, probably due to the relatively low moisture content of the unwilted silages. The only silage which was considered of poor quality and had a

TABLE 9.

Carotene content of grass silage under seven different treatments
(Expressed as micrograms of carotene, per gram of silage—dry basis)

Groups	Days after ensiling	Treatments							
		1	2	3	4	5	6	7	Mean
B	1	102.1	105.9	117.1	57.1	56.3	80.5	81.6	85.8
	7	*	*	75.2	42.5	78.8	79.7	*	69.1
	14	125.8	116.6	111.8	43.1	80.0	73.1	71.7	88.9
	30	135.4	129.4	137.0	67.8	98.5	109.2	115.7	113.3
	Mean	121.1	117.3	110.3	52.6	78.4	85.6	89.7	.....
C	1	*	*	*	*	114.4	85.9	75.5	91.9
	7	*	*	123.0	68.4	104.4	130.4	83.5	101.9
	14	195.3	179.1	148.1	127.8	129.1	133.3	90.0	143.2
	30	140.4	203.1	192.4	118.2	105.7	100.3	95.1	136.5
	Mean	167.9	191.1	154.5	104.8	113.4	112.5	86.0	.....

* Missing values due to loss of samples.

decidedly unpleasant odor was that prepared under treatment 1 of group A. Some of the samples, which had a moisture content of only 60 per cent, were of good quality but appeared quite dry and probably would not be the most palatable to cows. Even after 170 days, fermentation had not ceased in some of the silages prepared from wilted materials.

SUMMARY

1. On the basis of the results obtained in these experiments, it appears that the use of 2-quart glass jars as miniature silos offers a convenient technic for studies in silage preservation.

2. Desirable fermentation was obtained in all cases except the unwilted, untreated alfalfa silage. It should be noted that in the silages of groups B and C there was very little clover, and the crops were in full bloom.

3. The development of acidity was more rapid in the unwilted than in the wilted silages, and even after 170 days some of the wilted silages were still increasing in acidity. This characteristic was especially noticeable in the alfalfa group.

4. Using pH values as a measure of desirable fermentation, 60 lb. of molasses and 100 lb. of hominy feed, respectively, were equally effective as preservatives under the conditions of these experiments. Silages with straw added, and that wilted plus no preservative, were well preserved and of good quality, but were somewhat inferior to those in which preservatives were used.

5. There was no destruction of carotene in any of the silages up to 30 days following ensiling, an actual increase being noted in most cases.

6. The mean sugar content of the wilted silages was 40 and 33 per cent higher than for the unwilted silages in groups B and C, respectively.

7. The crude protein content of samples analyzed 60 days after ensiling was 4.90 per cent less than that of silage 1 day old. There also was a slight loss of crude protein, attributable to wilting.

8. Analysis of variance of dry matter, nitrogen, and pH values of the various silages studied here revealed a coefficient of variation of less than 5 per cent in all cases and less than 2 per cent in some instances. This extremely low variability indicates that very accurate sampling can be accomplished by using glass jars as miniature silos. Another important advantage of the miniature silo technic is that samples may be taken at any interval desired following the ensiling date.

9. Evidently the fermentation changes which occur in 2-quart glass jar silos are similar to those which occur in commercial silos.

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THE PLACENTAL TRANSFER AND COLOSTRAL STORAGE OF VITAMIN D IN THE BOVINE[1]

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The possible importance of prenatal and neonatal environment on the development and subsequent performance of dairy animals has been recognized for many years, but there is little experimental evidence bearing on this view. Recently several investigators (2, 15, 16, 23) have shown that the level of vitamin A in the newborn calf and in the colostrum is related directly to the vitamin A content of the prepartal diet. These investigations and the reports of rickets occurring in very young calves (1, 5) raised the question of the value of supplementing the prepartum diet with vitamin D.

The objective of the study reported herein was to determine the effect of prepartal diet and of season, respectively, on the level of vitamin D in the blood plasma of the pregnant cow, in the blood plasma and the liver of the newborn calf, and in the colostrum of the dam.

EXPERIMENTAL

Animals. Four groups of Holstein cows in the Cornell University herd were used in this experiment. The cows were allotted to an experimental group according to age, condition, health, ancestry, and previous performance. Two groups of four cows each were started on experiment during March, 1946, and one group of four cows and one group of five cows during August, 1946, to represent the latter part of the winter feeding period and the latter part of the pasture season, respectively. At each season one group of cows served as controls and the other group received a supplement of vitamin D. Each cow in the supplemented group was given 100,000 I.U. of vitamin D in the form of irradiated dry yeast[2] once a day for 8 weeks prepartum. The cows started on experiment in March were kept in the barn except for approximately 1 hour daily, when they were turned out for exercise in a cindered lot. The cows started on experiment in August were on pasture except for two periods of approximately 3 hours daily, when they were brought to the barn for feeding. The following summary gives the feeds fed and their carotene and vitamin D contents. Feed intakes were not recorded.

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[1] This paper is part of a thesis presented by H. D. Eaton to the Graduate School of Cornell University in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

[2] Capsules manufactured to contain 100,000 I.U. of vitamin D by Standard Brands, Inc., New York, N. Y.

Feed	*Description*	*Carotene ug./lb.*	*Vitamin D I.U./lb.*
	Spring, 1946		
Timothy hay	U. S. no. 2, first cutting at full bloom to late maturity, and field cured.	2,419	658
Corn silage	Fairly well-eared silage, early dent stage, containing 28 per cent dry matter on an air-dry basis.	6,532	70
Grain	A fitting ration consisting largely of cereal grains and containing 12 per cent total protein.	.....	.....
	Fall, 1946		
Timothy hay	U. S. no. 2, first cutting at late maturity, and field cured.	3,688	909
Corn silage	Well-eared corn silage, early to middle dent stage, containing 24 per cent dry matter on an air-dry basis.	3,289	68
Grain	A fitting ration consisting largely of cereal grains and containing 12 per cent total protein.	.....	.....
Pasture	Predominately bluegrass.	.....	.....

Samples. Maternal blood samples, taken at 8 weeks prepartum, before vitamin D supplementation, and at 2 weeks prepartum, were obtained between 7 and 8 a.m. from the jugular vein. Saturated aqueous sodium citrate was used as an anticoagulant. The sample was cooled to approximately 40° F., and centrifuged at 2,500 r.p.m. for 20 minutes. The plasma was siphoned off into 100-ml. sample bottles and held at approximately 0° F. until assayed for vitamin D.

Calves were slaughtered within 3 hours after birth and before they had nursed. Blood plasma was treated as described above. Livers from calves born in the spring of 1946 were cooled to 38° F., cut into small pieces, placed on an enamel tray in an oven which had a constant circulation of air provided by an electric fan, and held at 60° C. for 24 hours. At the end of this period, they were removed from the oven, allowed to reach a constant weight at room temperature, ground in a Wiley mill, and held at 38° F. until assayed for vitamin D. After chilling to 38° F., livers from calves born in the fall of 1946 were frozen at 0° F., cut into small pieces, placed on small wire baskets in Pyrex glass desiccators containing phosphoric anhydride, and dried for 4 days under a partial vacuum. After drying, the livers were finely ground in a meat grinder and held at approximately 0° F. until assayed for vitamin D. The livers from calves born in the fall were freeze-dried because it was thought that some vitamin D might have been destroyed in the oven-drying procedure originally used. Limited data (10), however, do not indicate an appreciable difference in the two methods of drying.

The cows were milked twice daily and the colostrum was collected from the first six milkings postpartum. The colostrum was held at 34° F. until all six milkings were obtained. The entire yield of colostrum was heated to

100° F., separated with a centrifugal separator, and an aliquot of the resulting cream was held at 38° F. until assayed for vitamin D.

Analyses. Vitamin D determinations[3] were made according to the rat assay method essentially as set forth in the U. S. Pharmacopoeia XII (19). The approximate level of each type of sample to be fed was determined by preliminary assays. Photographs were made of the stained bones as a matter of record.[4] The vitamin D content was calculated by establishing an equation for a curve of response essentially as outlined by Coward (3). In the case of the colostrum, it was assumed that the vitamin D was contained only in the fat portion. Therefore, the fat content of the colostrum and colostrum cream was determined by means of the standard Babcock procedure.

The data were treated statistically by analysis of variance to determine significance as described by Snedecor (14). Due to the limited number of observations, only those differences significant at the 1 per cent level are reported as statistically significant in the results.

RESULTS

Maternal blood plasma vitamin D values are listed in table 1. Vitamin D

TABLE 1

Effect of prepartum vitamin D supplementation on maternal plasma vitamin D

March–April			Aug.–Sept.		
No. of cow	Plasma vitamin D		No. of cow	Plasma vitamin D	
	8 weeks* prepartum	2 weeks prepartum		8 weeks* prepartum	2 weeks prepartum
	(*I.U./100 ml.*)			(*I.U./100 ml.*)	
Controls					
101	72	162	121	466	.....
107	.....	.....	129	351	163
111	85	171	131	193	324
Mean ± S.E.	79 ± 6	167 ± 4	.....	337 ± 79	244 ± 85
Vitamin D supplemented					
104†	115	439	122	278	475
108	81	160	126	337	306
112	112	247	128	425	437
Mean ± S.E.	103 ± 11	282 ± 82	.....	347 ± 43	406 ± 51
All cows					
Mean ± S.E.	93 ± 9	.....	.....	342 ± 40	.....

* Before supplementation with vitamin D.

† This cow was fed 200,000 I. U. daily of vitamin D 8 weeks prepartum.

[3] These assays were made by the Laboratory of Industrial Hygiene, Inc., 76 Madison Ave., New York, N. Y., under the direction of Miss Grace McGuire.

[4] Complete reports are on file in the Department of Animal Husbandry, Cornell University.

increased to a higher level in the supplemented cows than in the controls, although this difference was not statistically significant. There was a statistical difference between seasons, the level of vitamin D being on an average two to three times higher during the fall than during the spring.

The vitamin D content of plasma of newborn calves is presented in table 2. Calves from supplemented dams tended to be higher in plasma vitamin D in the spring and slightly lower in the fall as compared to calves from control dams. There is an indication of a seasonal trend. Calves from both groups in the fall had higher plasma vitamin D levels than calves born in the spring. Neither the treatment difference nor the seasonal difference was statistically significant.

TABLE 2

Effect of prepartum vitamin D supplementation on plasma vitamin D in the newborn calf

April–May		Sept.–Oct.	
No. of dam	Vitamin D in plasma (*I.U./100 ml.*)	No. of dam	Vitamin D in plasma (*I.U./100 ml.*)
Controls			
101	32	121	131
107	55	129	126
111	52	131	75
Mean ± S.E.	46 ± 7	.....	111 ± 18
Dams vitamin D supplemented			
104*	111	122	95
108	73	126	91
112	42	128	91
Mean ± S.E.	75 ± 20	.....	92 ± 1

* Dam fed 200,000 I.U. daily of vitamin D 8 weeks prepartum.

No consistent differences were found between the vitamin D content of the livers of the newborn calves from the supplemented dams and from the control dams, as shown in table 3. On the other hand, there was an apparent seasonal trend. Both groups of calves born in the fall had higher levels of liver vitamin D than the calves born in the spring. This difference was not statistically significant.

The vitamin D values for colostrum are presented in table 4. The average vitamin D content of the colostrum was consistently higher in the supplemented groups than in the control groups. This difference was not statistically significant when comparing treatments at either season alone; however, when both seasons together were compared, this difference was statistically significant. There was a seasonal trend in colostrum vitamin D levels. The values during the fall were materially higher than those in the

TABLE 3

Effect of prepartum vitamin D supplementation on the vitamin D content of the liver in the newborn calf

No. of dam	Birth weight	Liver		
		Fresh weight	I.U./g.	Total I.U. in liver
	(*lb.*)	(*g.*)		
April–May—Controls				
101	97	850	0.08	68
107	86	846	0.14	118
111	107	1064	0.06	64
Mean ± S.E.	.....	.....	0.09 ± 0.02	83 ± 17
April–May—Dams vitamin D supplemented				
104*	81	648	0.20	130
108	86	655	0.07	46
112	89	667	0.06	40
Mean ± S.E.	.....	.....	0.11 ± 0.05	72 ± 29
Sept.–Oct.—Controls				
121	96	1115	0.30	334
129	100	862	0.16	138
131	92	661	0.16	106
Mean ± S.E.	.....	.....	0.21 ± 0.05	193 ± 71
Sept.–Oct.—Dams vitamin D supplemented				
122	82	642	0.21	135
126	100	903	0.21	190
128	90	663	0.05	33
Mean ± S.E.	.....	.....	0.16 ± 0.05	119 ± 46

* Dam fed 200,000 I.U. daily of vitamin D 8 weeks prepartum.

spring. The only statistically significant difference between seasons was the vitamin D content per pound of colostrum.

DISCUSSION

These data, although limited in number and in general exhibiting a high degree of variability, do indicate certain trends.

The prepartum blood plasma levels of vitamin D are in agreement with the work of Light *et al.* (8), Wallis (21), and Hibbs *et al.* (7) in that the level of plasma vitamin D is related to the dietary intake of vitamin D. Seasonal differences in blood plasma vitamin D have been noted earlier by Wallis (21). Wallis (20) has questioned the efficacy of sunlight as being entirely responsible for the higher levels of plasma vitamin D found during the summer months.

The levels of vitamin D in the blood plasma and liver of the newborn calf indicate little storage in these tissues and are suggestive of limited placental transfer at the levels fed. In this experiment, no apparent in-

TABLE 4

Effect of prepartum vitamin D supplementation on colostrum vitamin D

No. of cow	Colostrum		Vitamin D content of colostrum		
	Total 3-day yield	Fat	I.U./g. of fat	I.U./lb. of colostrum	Total I.U. in 3-day yield
	(*lb.*)	(%)			
April–May—Controls					
101	170	6.8	0.65	20	3409
107	110	3.3	1.06	16	1746
109	165	3.8	1.13	19	3214
111	96	5.2	0.72	17	1630
Mean ± S.E.	180 ± 19	4.8 ± 0.8	0.89 ± 0.12	18 ± 1	2500 ± 471
April–May—Vitamin D supplemented					
104*	148	4.2	4.06	76	11278
106	165	5.5	3.49	87	14367
108	102	4.0	1.96	36	3627
112	106	5.6	1.66	42	4470
Mean ± S.E.	130 ± 16	4.8 ± 0.4	2.78 ± 0.57	60 ± 12	8436 ± 2616
Sept.–Oct.—Controls					
127	88	4.8	0.70	15	1341
129	57	2.5	0.83	9	536
131	66	4.4	2.53	50	3332
133	124	4.5	3.18	65	8049
Mean ± S.E.	84 ± 15	4.1 ± 0.5	1.81 ± 0.62	35 ± 13	3314 ± 1684
Sept.–Oct.—Vitamin D supplemented					
122	48	3.9	5.12	91	4347
126	113	5.5	6.52	163	18381
128	89	6.1	8.12	225	19997
132	107	4.4	2.01	40	4293
Mean ± S.E.	89 ± 15	5.0 ± 0.5	5.44 ± 1.30	130 ± 40	11755 ± 4305

* This cow was fed 200,000 I.U. daily of vitamin D 8 weeks prepartum.

crease was obtained. Since Toverud and Ender (18) have reported that the level of vitamin D contained in livers of stillborn infants is related to the prepartal diet of the mother, it is possible that the level of prepartal supplementation of vitamin D used in this experiment was not sufficiently high to demonstrate an increase. Guerrant *et al.* (4) have suggested that the differences in the vitamin D content of blood plasma and liver at 6 months of age of calves born in September as compared to those levels found in calves born in November were due to prenatal influence. The data reported herein would seem to substantiate this view.

The colostral storage of vitamin D was found to be related to dietary intake of vitamin D. Polskin *et al.* (13) concluded that prepartal feeding of fish liver oil was not an effective way to increase the vitamin D content of mother's milk. They did observe a variable increase in the vitamin D content of milk samples drawn the first 7 to 9 days postpartum from mothers

fed prepartum varying amounts of fish liver oil. The level of vitamin D in the milk of the cow has been found to be related to the dietary intake of vitamin D and, in addition, seasonal trends in the vitamin D content of milk have been reported and correlated with the amount of sunshine (22).

The value of prepartal vitamin D supplementation to the cow and the newborn calf was not determined. Hibbs *et al.* (6) have not been successful in preventing milk fever by prepartal supplementation of vitamin D. In other species there have been reports (9, 11, 12, 17) of possible beneficial results to the mother and her newborn.

SUMMARY

The effects of supplementing the dry cow ration with 100,000 I.U. of vitamin D in the form of irradiated yeast once daily for 8 weeks prepartum at two different seasons of the year have been studied. The following results were obtained:

1. An increase in the vitamin D content of the blood plasma was observed in those cows receiving the vitamin D supplement as compared to those levels obtained in the non-supplemented cows.
2. No consisteint differences were found in the vitamin D content of blood plasma and liver of newborn calves from supplemented dams as compared to newborn calves from control dams.
3. The colostral storage of vitamin D was materially increased by prepartal supplementation of vitamin D.
4. There was a seasonal trend in vitamin D content of maternal blood plasma, blood plasma and liver of the newborn calf, and colostrum. The values obtained during the latter part of the pasture season were materially higher than those values obtained at the latter part of the spring feeding period.

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THE EFFECT OF A MASSIVE DOSE AT BIRTH OF VITAMINS A AND D UPON BLOOD PLASMA LEVELS AND LIVER STORAGE IN HOLSTEIN CALVES[1]

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Inasmuch as the newborn calf usually is deficient in vitamins A and D, and colostrum supplies variable amounts of these essentials, it has been suggested that a massive dose of these vitamins at birth might be beneficial to the young calf. Hibbs and Krauss (6) have shown that feeding large amounts of vitamin A on the third and tenth day of age maintained higher-than-normal blood plasma levels and liver storage of vitamin A for a period of 30 days.

The study reported herein was undertaken to determine the effect of a single massive dose of vitamins A and D at birth on the level of carotene, vitamin A, and vitamin D in the blood plasma from birth to 42 days of age, and on the storage of carotene, vitamin A, and vitamin D in the liver at 84 hours of age.

EXPERIMENT I

Animals. Twelve purebred Holstein calves born in the Cornell University herd during March, April, and May, 1946, were used for the studies on blood plasma. They were placed in individual pens at birth. The dams of these calves received similar prepartum treatment. Two vitamin pellets,[2] each containing 125,000 I.U. of vitamin A, 25,000 I.U. of vitamin D, and 250 mg. of niacin chloride, were given by balling gun to alternate calves at the time of the first feeding of colostrum. The feeding schedule was as follows:

Age (days)	*Feed*
1–3	6 lb. of colostrum
4–7	6 lb. of herd milk
8–14	7 lb. of herd milk
15–35	8 lb. of herd milk and free access to calf starter and hay
36–42	6 lb. of herd milk and free access to calf starter and hay

The first feeding was 4 hours after birth and twice daily thereafter. Nipple pails were used for the first 28 days. The colostrum, which was

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[2] Manufactured by Standard Brands, Inc., New York, N. Y.

collected from cows fed winter rations, was pooled and held at 0° F. It contained 254 μg. of carotene, 1,143 μg. of vitamin A, and 23 I.U. of vitamin D per lb. The Holstein herd milk was produced under winter feeding conditions. An aliquot of daily samples of this herd milk collected during the course of the experiment contained 48 μg. of carotene, 95 μg. of vitamin A, and 10 I.U. of vitamin D per lb. The hay was predominantly second-cutting U. S. no. 1 timothy and contained 11,105 μg. of carotene and 980 I.U. of vitamin D per lb. The calf starter contained 862 μg. of carotene and 1,347 I.U. of vitamin D per lb. The calves had free access to water at all times.

The possibility of infectious scours was eliminated by giving each calf 4 g. of sulfathalidine twice daily by balling gun for the first 3 days after birth, and once daily for the next 7 days. Later cases of scours were treated by reducing the allowance of milk and feeding a mixture of kaolin, pectin, and sulfathiazole. Incidence and severity of scours were recorded. Calves were weighed at birth and once weekly thereafter.

Samples. Blood samples were obtained at the end of the colostral feeding period (3 days) and at weekly intervals thereafter. These samples were drawn between 7 and 8 a.m. from the jugular vein, and saturated aqueous sodium citrate was used as an anticoagulant. The samples were cooled to approximately 40° F., and all but 2 to 5 ml. (for total hemoglobin determination) were centrifuged at 2,500 r.p.m. for 20 minutes. Vitamin A and carotene and total blood hemoglobin were determined the same morning the samples were drawn. The remainder of the plasma was held at 0° F. until assayed for vitamin D.

Analyses. Blood plasma vitamin A and carotene were determined by the method of Kimble (8), and total blood hemoglobin by the method of Evelyn and Malloy (4). An Evelyn photoelectric macrocolorimeter was used; it previously had been standardized against crystalline carotene in petroleum ether and against crystalline vitamin A in chloroform.

Vitamin D determinations[3] were made according to the rat assay method essentially as set forth in the U. S. Pharmacopoeia XII (17). The approximate level of each type of sample to be fed was determined by preliminary assays. Photographs[4] were made of the stained bones as a matter of record. The vitamin D content was calculated by establishing an equation for a curve of response essentially as outlined by Coward (2).

The data were treated statistically by analysis of variance to determine significance as described by Snedecor (13). Due to the limited number of observations, only those differences significant at the 1 per cent level are reported as statistically significant in the results.

[3] These assays were made by the Laboratory of Industrial Hygiene, Inc., 76 Madison Ave., New York, N. Y., under the direction of Miss Grace McGuire.

[4] Complete records are on file in the Department of Animal Husbandry, Cornell University.

Results. The blood plasma level of carotene, vitamin A, and vitamin D, and the total hemoglobin of whole blood are presented in table 1.

The carotene content was significantly lower throughout the entire experimental period for calves fed the supplementary vitamins. For any one age this difference was not statistically significant. Both groups of calves showed a significant elevation of blood plasma carotene with an increase in age. There was significant variation among calves within a group during the experimental period.

TABLE 1

*The effect of a massive dose at birth of vitamins A and D upon plasma carotene, vitamin A, vitamin D, and total hemoglobin from 3 to 42 days of age**

	Age (days)					
	3	14	21	28	35	42
Carotene—μg./100 ml. plasma						
Controls	6.7 ± 1.5	10.5 ± 2.4	13.7 ± 2.6	14.8 ± 2.3	21.2 ± 2.1	25.8 ± 3.4
Vitamin-supplemented	7.7 ± 2.0	8.5 ± 2.2	12.8 ± 1.9	14.3 ± 1.5	13.0 ± 2.2	17.3 ± 3.4
Vitamin A—μg./100 ml. plasma						
Controls	15.3 ± 2.6	11.5 ± 1.4	12.0 ± 1.7	8.4 ± 1.7	10.4 ± 1.4	10.9 ± 1.4
Vitamin-supplemented	22.7 ± 3.8	17.1 ± 2.3	12.3 ± 1.2	13.4 ± 2.0	14.3 ± 1.7	14.4 ± 1.8
Vitamin D—I.U./100 ml. plasma						
Controls	67 ± 13		40 ± 11			55 ± 7
Vitamin-supplemented	151 ± 38		148 ± 18			90 ± 12
Total hemoglobin—g./100 ml. whole blood						
Controls	10.46 ± 0.37	10.09 ± 0.38	9.43 ± 0.50	8.24 ± 0.38	8.36 ± 0.40	8.67 ± 0.28
Vitamin-supplemented	10.87 ± 0.45	10.51 ± 0.38	9.50 ± 0.42	8.34 ± 0.39	8.55 ± 0.19	8.82 ± 0.34

* Each value represents the mean ± standard error for 6 calves.

The level of vitamin A in the blood plasma of the vitamin supplemented calves was significantly higher than that of the controls throughout the entire experimental period. At any one age this difference was not statistically significant. Calves within a group varied significantly with age and among individuals.

Blood plasma vitamin D values were significantly higher during the entire experimental period for the vitamin-supplemented calves. For any particular time, the only statistically significant difference was at 21 days of age. Calves within a group did not exhibit statistically significant differences with age or among individuals.

Total hemoglobin was determined to establish some normal values for calves raised on a limited whole milk-dry calf starter method. No signifi-

cant difference in the total hemoglobin level between groups was observed. Calves decreased significantly in the total hemoglobin level with an increase in age. Significant variation was found among individual calves.

No significant differences were found in the consumption of starter or hay, liveweight increases, and incidence or severity of scours.

EXPERIMENT II

Animals. Six purebred Holstein calves dropped in the Cornell University herd during June, July, and August, 1946, were used in the experiment on storage in the liver. They were placed in individual pens at birth. The dams of these calves received similar prepartum treatment. Two vitamin pellets identical to those previously described were given by balling gun to alternate calves at the time of the first feeding of colostrum. The feeding schedule was as follows:

Age (hours)	*Feed**
6	3 lb. colostrum
18	3 lb. colostrum
30	3 lb. colostrum
42	3 lb. colostrum
54	3 lb. reconstituted skim milk
66	3 lb. reconstituted skim milk
84	Calf slaughtered

* Calves nos. 2 and 11 were fed colostrum and reconstituted skim milk in amounts representing 8 per cent of their liveweight at birth.

Nipple pails were used throughout the experiment. The colostrum, which was collected from Holstein cows which had been on pasture prior to calving, was pooled and held at 0° F. This colostrum contained 528 μg. of carotene, 504 μg. of vitamin A, and 24 I.U. of vitamin D per lb. Carotene and vitamin A were not detected in the dried skim milk.

Samples. Blood samples were drawn before each feeding and at the time of slaughter. Treatment of these samples was identical to that described in experiment I.

The livers were cooled to 38° F., cut into small pieces, and placed on an enamel tray. Aliquots were taken for carotene and vitamin A analyses; the tray then was placed in an oven which had a constant circulation of air provided by an electric fan, and held at 60° C. for 24 hours. The livers then were removed from the oven, allowed to reach a constant weight at room temperature, ground in a Wiley mill, and held at 38° F. until assayed for vitamin D.

Analyses. The analytical methods and statistical treatments used were identical to those described in experiment I. The carotene and vitamin A contents of the livers were determined by the method of Davies (3) within 48 hours after slaughter.

TABLE 2

*The effect of a massive dose at birth of vitamins A and D upon plasma carotene and plasma vitamin A from 6 to 84 hours of age**

Age	Carotene μg./100 ml. plasma		Vitamin A μg./100 ml. plasma	
	Controls	Vitamin-supplemented	Controls	Vitamin-supplemented
(*hr.*)				
6	3.0 ± 1.0	2.3 ± 1.5	5.3 ± 3.0	5.7 ± 3.1
18	4.7 ± 0.9	4.7 ± 1.8	8.4 ± 4.9	24.6 ± 15.3
30	9.3 ± 1.3	9.7 ± 3.5	10.5 ± 5.4	29.7 ± 18.0
42	13.0 ± 2.1	13.7 ± 3.0	12.6 ± 6.6	17.6 ± 9.2
54	17.0 ± 1.0	18.7 ± 3.5	15.1 ± 8.4	30.7 ± 20.7
66	13.7 ± 0.9	19.0 ± 2.5	11.7 ± 6.3	89.8 ± 48.0
84	14.7 ± 1.8	16.3 ± 2.6	9.6 ± 5.3	28.9 ± 15.4

* Each value represents the mean ± standard error for 3 calves.

Results. The level of carotene and vitamin A in the blood plasma is presented in table 2. Plasma carotene was not significantly different between groups. There was a tendency for the level of carotene in the plasma to drop after the feeding of reconstituted skim milk. Calves within a group varied significantly in plasma carotene levels. The level of vitamin A in the blood plasma was significantly higher in the vitamin-supplemented calves for the entire experimental period. A marked elevation in plasma vitamin A resulted in the vitamin-supplemented calves after a feeding of reconstituted skim milk. Calves within a group showed significant variation with age and among individuals.

The mean blood plasma level of vitamin D at 84 hours of age was 42 ± 13 I.U. for the controls and 154 ± 27 I.U. for the vitamin-supplemented calves. This difference, although marked, was not statistically significant.

The carotene, vitamin A, and vitamin D contents of the livers are presented in table 3. Liver carotene was approximately the same for both

TABLE 3

*The effect of a massive dose at birth of vitamins A and D upon the liver carotene, liver vitamin A, and liver vitamin D at 84 hours of age**

Carotene†		Vitamin A†			Vitamin D†	
μg./g. liver	Total μg. in liver	μg./g. liver	Total μg. in liver	Total I.U. in liver‡	I.U./g. liver	Total I.U. in liver
Controls						
0.53 ± 0.07	421 ± 78	4.26 ± 0.86	3267 ± 623	13770 ± 2398	0.14 ± 0.04	110 ± 26
Vitamin supplemented						
0.63 ± 0.12	442 ± 74	62.01 ± 5.96	43579 ± 2147	175054 ± 8709	2.24 ± 0.21	1606 ± 235

* Each value represents the mean ± standard error for 3 calves.
† Expressed on a wet basis.
‡ Assuming 0.6 μg. carotene = 1 I.U. of vitamin A and 0.25 μg. vitamin A = 1 I.U. of vitamin A.

groups of calves. The levels of vitamin A and vitamin D were ten times higher in the vitamin D-supplemented calves than in the control calves, and these differences were statistically significant.

DISCUSSION

These data indicate that the blood plasma level of vitamins A and D may be maintained at a level higher than normal by the administration of a massive dose of these vitamins at birth to the Holstein calf. The apparent reason for this is the relatively high liver storage obtained after the administration of these vitamins.

The general trends of the levels of carotene and vitamin A in the blood plasma of the control calves are in agreement with those reported by Moore and Berry (11, 12) for Holstein calves.

The depression of the carotene level in the blood plasma from 3 to 42 days of age in those calves fed the vitamin supplement has been observed previously in lactating cows fed relatively high doses of vitamin A. This recently has been discussed by Wise *et al.* (18). The mechanism involved is yet unknown. Apparently considerable time is necessary for the factor or factors which cause this depression in plasma carotene to act, for no such depression was noted until the second week after administration of the large dose of vitamin A.

The maintenance of higher-than-normal blood plasma levels of vitamin A in the vitamin-supplemented calves is in agreement with the work of Sutton and Kaeser (16) and Hibbs and Krauss (6). A massive dose of vitamins at birth is as effective as daily doses or two massive doses at 3 and 10 days of age in maintaining high blood plasma levels of vitamin A.

After a feeding of reconstituted skim milk, there was a marked elevation in the blood plasma level of vitamin A in those calves receiving the vitamin supplement. Apparently at high levels of liver storage of vitamin A there is a mobilization of the vitamin A from the liver and other depots into the blood stream.

By the administration of a single massive dose of vitamin A at birth to the calf it is possible to obtain greater liver storage of total vitamin A than that obtained by prepartal feeding, as reported by Spielman *et al.* (15). Although the administration of vitamins at birth is more economical, the possible benefit to the calf in its intrauterine development through prepartum supplementation of its dam with vitamin A should not be overlooked. Studies by Hibbs and Krauss (6) and Spielman *et al.* (14) have shown that massive doses of vitamins have not resulted in improved performance.

It should be noted that the vitamin pills used contained niacin chloride. The influence of the sparing action of niacin on vitamin A (10) may be disregarded, since recently Johnson *et al.* (7) have found niacin to be unessential in the diet of the calf. Moreover, Hibbs and Krauss (6) have re-

ported no effect on blood plasma levels or liver storage of vitamin A with the daily addition to the diet of 50 mg. of niacin.

The small recovery of vitamin D in the livers of the vitamin-supplemented calves is in agreement with the work of Guerrant *et al.* (5). These workers found relatively small differences in liver storage of vitamin D with wide difference in dietary intake of vitamin D. A possible loss of vitamin D in the oven-drying method has been investigated by Loosli *et al.* (9). Preliminary evidence indicates no appreciable loss between oven-dried and freeze-dried liver.

The decrease in total hemoglobin with an increase in age in young calves has been observed previously by Anderson *et al.* (1) and by others.

SUMMARY

The effect of a massive dose of vitamins A and D fed to Holstein calves at birth has been studied. The following results were obtained:

1. A significant depression in the levels of carotene in the blood plasma occurred in those calves which received the vitamin supplement as compared to those in the control group. This depression was apparent 2 weeks after the administration of the massive dose of vitamins and continued until the end of the experimental period at 6 weeks of age. The levels of both vitamin A and vitamin D in the blood plasma of the vitamin-supplemented calves were significantly higher than those levels for the control calves.

2. The storage of vitamins A and D in the livers of the vitamin-supplemented calves was ten times higher than that found in the control calves. No appreciable differences in liver carotene storage were observed.

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ABSTRACTS OF LITERATURE

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MILK AND MILK PRODUCTS

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ABSTRACTS OF LITERATURE

BACTERIOLOGY

328. Places Where Practice in Making Laboratory Examinations of Dairy Products Has Not Caught Up with Research Findings. R. S. BREED, New York State Expt. Sta. (Cornell University), Geneva. Milk Indus. Found. Assoc. Bul., *39*, 15: 431–447. May, 1947.

The various conditions under which milk is produced, processed, contaminated, held in storage, and modified by addition of such materials as chocolate, vitamin D, etc., make for wide variation in the types of bacteria which may be present. A laboratory using only one temperature of incubation many times will be in error unless additional plates at other temperatures are used or if agar plates are not checked with microscopic preparations. Curves are presented showing in general a higher colony plate count on plates incubated at 48 hr. at 32° C. than for the same length of time at 35° C. or 37° C. A temperature of 32° C. is recommended.

The problem of coliform standards is suggested as one for individual enforcement officers, since reasonable standards will vary from one milk area to another. The Montreal milk supply is reported to meet standards of less than 1 coliform organism per ml. of milk, while the upstate New York inspectors have not found it advisable to enforce a standard more severe than 10 coliforms per ml. Long storage periods to which pasteurized milk frequently is subjected cause bacteriological conditions about which more information is needed and upon which more research should be done.

E.F.G.

329. L'analyse bacteriologique des laits concentrés sucrés. Presence de staphylocoque pathogènes dans certains d'entre eux. (Bacteriological Analysis of Sweetened Condensed Milks. Presence of Staphylococcic Pathogens in Certain of Them.) R. BUTTIAUX AND L. LESNE, Pasteur Institute, Lille, France. Le Lait, *27*, 263–264: 121–131. March–April, 1947.

In 1945, samples of sweetened condensed milk of foreign origin were found to produce serious illnesses among infants. Details are given of the bacteriological methods used in studying samples of this product and the results secured. Cans were examined for swelling, for total and *B. coli* count, and for the presence of putrid organisms, anaerobes, yeasts, ropy organisms, and salmonella.

In isolating and identifying the staphylococci, Gram stains were made of cultures obtained in lactose broth. These were cultured on nutrient agar containing tryptone and glucose. After 24 hr. at 37° C., typical golden and white colonies were picked for further study. Pathogenic strains were distinguished by color of colony, coagulation of blood serum, haemolysis, fermentation of mannitol, and production of violet color on lactose gentian-violet agar.

Of 66 different samples examined, 20 showed the presence of staphylococci, and 16 of these were pathogenic. Numbers varied from 100 to 100,000 per l., but types rather than numbers appeared more important in determining the severity of the sickness which occurred. Contamination of these products probably took place during processing rather than from organisms present in the raw milk surviving heat treatment. O.R.I.

BUTTER

330. **Milk Fat Concentrate Process.** H. C. Horneman, R. V. Hussong, S. N. Quam, and B. W. Hammer. (Assigned to Sugar Creek Creamery and Cherry Burrell Corp.) U. S. Patent 2,423,834, July 15, 1947 (6 claims). U. S. Patent Office Off. Gaz., *600*, 3: 382. 1947.

Cream under reduced pressure is subjected to the action of steam, then centrifuged to yield milk fat, mixed with water and salt, and finally suitably cooled and stabilized to produce a product like butter. R.W.

CHEESE

331. **Flavor Development in Cheddar Cheese.** A. C. Dahlberg and F. V. Kosikowsky, Cornell University, Ithaca, N. Y. Natl. Butter and Cheese Jour., *38*, 8: 44. Aug., 1947.

The formation of the flavor compounds in Cheddar cheese has never been fully explained by scientific knowledge. It is known that during ripening carbon dioxide is formed, lactose disappears, pH decreases and then increases, protein decomposes into simpler nitrogenous compounds and amino acids, and volatile fatty acids are formed. These changes are caused by the combined actions of bacteria and of enzymes added with rennet extract. Science has not determined any exact relationship of protein decomposition and development of volatile fatty acids to intensity of flavor production. It is known, however, that high temperatures of curing tend to stimulate these changes that are observed as flavor is produced in cheese made from pasteurized milk and from raw milk of high quality. New methods must be used to study these problems. W.V.P.

332. Étude comparée des fromages de Livarot et de Pont-L'Évêque. (Study Comparing Livarot and Pont-L'Eveque Cheeses.) C. HUBEL AND G. MOCQUOT. Le Lait, *27*, 263–264: 131–141. March–April, 1947.

The characteristics of, and to a limited extent, the methods used in manufacturing these two varieties of cheese are described. Both types are products of the district of d'Auge in Normandy.

Livarot, a small cylindrical cheese about 12 cm. in diameter and 5 cm. tall, requires much care during the 3 months of ripening. It is made from partially skimmed milk, the finished cheese containing 30 to 40% fat in the dry matter. Acidity develops rapidly during manufacture, although the development of proper flavor and texture is dependent upon the growth of a surface coat containing yeasts, molds, and proteolytic bacteria. Pont-L'Évêque, a square cheese with dimensions of 11 cm. a side, is made from whole, fresh milk with rennet and is ready for consumption in 4 to 6 weeks. An orange-tinted slime develops on the surface of the cheese during ripening.

Graphs are presented showing comparative rates of lactic acid development, reduction in weight and moisture content during ripening, variations in pH during ripening, and rate of salt penetration. O.R.I.

CHEMISTRY

333. Calcium Content of Fluid Milk. C. H. ROBINSON, I. HLYNKA, F. A. HERMAN, AND J. W. MCARTHUR, Dept. of Agr., Ottawa, Canada. Canad. Public Health Jour., *38*, 5: 236–239. May, 1947.

The calcium content of fluid milk was determined at weekly intervals for 1 year (Oct., 1944–Oct., 1945) from representative dairies in Ottawa, Ont., Kentville, N. S., and Summerland, B. C., and continuous line charts were plotted from the results. There is a suggestion of a midwinter and midsummer fall in the curves. Mean values for the three localities were 117, 112, and 139 mg. Ca per 100 ml. milk, respectively, indicating a highly significant difference. Milks from individual dairies in Ottawa yielded nearly identical mean values, but there was a difference between dairies in the other two areas.

Other areas might yield calcium values lower than those found in the Ottawa data. If an error of $\pm 20\%$ is too great for purposes of dietary survey, the mean calcium content of the fluid milk for the area under survey should be determined. O.R.I.

334. Milk Studies. I. Some Vitamin and Trace Elements Found in the Colostrum of the Dairy Cow, Beef Cow, and Swine. R. W. LUECKE, C. W. DUNCAN, R. E. ELY, E. JONES, A. J. GREENE, AND

C. TULL, Michigan State College, East Lansing. Arch. Biochem., *13*, 2: 277. May, 1947.

Essentially the same concentrations of iron, copper, and cobalt were found in the colostrum milk of the beef cow and of the Jersey and Holstein dairy cow. The iron and copper contents of colostrum from both dairy and beef cows were found to be higher than values reported for milk. Carotene and vitamin A contents of colostrum milk from the Jersey cow averaged 0.347 and 0.401 mg./100 ml., respectively, as compared with 0.100 and 0.052 mg./100 ml. in Holstein colostrum, and 0.129 and 0.145 mg./100 ml. in colostrum of the beef cow. H.J.P.

335. **Recherches sur les variations du taux du lactose dans le lait de vache pendant le travail.** (Studies on the Variations in the Lactose Content of Milk of Cattle during Work.) A. PINO. Le Lait, *27*, 263–264: 113–121. March–April, 1947.

Physiological evidence indicates that muscle activity and the production of lactose in milk are competitive in their demands upon stored sources of energy in the animal organism. The possibility that cows which were used as work animals would yield milk containing smaller percentages of lactose was investigated. Lactose analyses were made on milk samples from 50 cows at rest, after 1, 2, 3, and 4 hr. work, and after 1, 2, 3, 4, and in some cases 5, 6, and 7 hr. rest. Only ten of the cows were accustomed to working.

The lactose content of the milk of both groups declined during work and was restored by rest, the diminution being more marked in the group not accustomed to working. However, the lactose content of the "working" cows was low at all times, in some cases being less than 2%. O.R.I.

336. **Composition of Buffalo Milk Fat.** C. P. ANANTAKRISHNAN, V. R. BHALERAO, AND T. M. PAUL, Indian Dairy Research Inst., Bangalore, India. Arch. Biochem., *13*, 3: 389. June, 1947.

The influence of feeding oils and fats on the composition of buffalo milk fat was determined. When a basal ration was supplemented by coconut oil and its hydrogenated product, a significant increase in the lauro-myristic group and a marked fall in palmitic acid occurred. Cottonseed oil supplementation reduced the amount of the lower saturated acids up to palmitic acid and increased the content of oleic and stearic acids. Ingestion of groundnut and sesame oils led to an increase in the oleoglycerides of the resulting milk fat with a corresponding decrease in palmitoglycerides. The selective adsorption of lauro-myristic glycerides by the mammary gland indicates that the mechanism of secretion of fat by buffaloes is almost similar to that of cows. H.J.P.

337. Direct Estimation of Leucine (Application to Milk and Certain Other Foodstuffs). A. Z. HODSON AND G. M. KRUEGER, Pet Milk Co., Greenville, Ill. Arch. Biochem., *12*, 3: 435. March, 1947.

The leucine content of dry skim milk and dry whole milk was determined by two microbiological methods. Direct assays of unhydrolyzed samples of skim milk conducted with a "leucineless" mutant of *Neurospora crassa* averaged 4.01% leucine; dry whole milk averaged 3.16% leucine. Acid hydrolyzed samples of skim milk assayed with *Streptococcus faecalis* averaged 4.08% leucine, and dry whole milk averaged 3.09% leucine. H.J.P.

338. Preparation and Properties of Serum and Plasma Proteins. XIII. Crystallization of Serum Albumins from Ethanol-Water Mixtures. E. J. COHN, W. L. HUGHES, JR., AND J. H. WEARE, Harvard Medical School, Boston, Mass. Amer. Chem. Soc. Jour., *69*, 7: 1753. July, 1947.

Long chain aliphatic alcohols of 5 or more carbon atoms permitted the reproducible crystallization of serum albumins from ethanol-water mixtures. Bovine serum albumins crystallized readily over the following range of solvent composition: ethanol volume per cent at 25°, 33 to 40; mole fraction, 0.12 to 0.163; ionic strength, 0.32 to 0.65; pH, 5.3 to 5.7; temperature, +5 to −10° C.; and 10 to 20% protein concentration. Constants defining the properties of purified serum albumins are tabulated. H.J.P.

339. Three Sources of Amino Acids for Niacin Assay. A. R. KEMMERER AND F. SHAPIRO, Univ. of Arizona, Tucson. Indus. and Engin. Chem., Analyt. Ed., *19*, 5: 358–359. May, 1947.

In the Snell-Wright microbiological assay for niacin, acid-hydrolyzed casein has been used as a source of amino acids for the assay organism. This comparison of trypsin-hydrolyzed casein and charcoal-treated peptone with acid-hydrolyzed casein indicates that any of these sources of amino acids will give reliable results. Some characteristics of each amino acid preparation are discussed. B.H.W.

CONCENTRATED AND DRY MILK; BY-PRODUCTS

340. Flavor and Color of Sweetened Condensed Milk. G. C. NORTH, Beatrice Foods Co., Chicago, Ill. Milk Plant Monthly, *36*, 7: 38. 1947.

Sweetened condensed milk will possess a fine fresh milk flavor over an extended period if the product is made from high quality milk in properly sanitized equipment, free of copper contamination, and heated sufficiently

to inactivate the enzyme lipase. Rancidity and tallowiness are two possible flavors of sweetened condensed milk. Progressive darkening is quite noticeable when dextrose or corn sirup is used as part of the sweetening agent and the product is held at a high temperature. Cool storage is essential in order to retard the development of a dark color. G.M.T.

341. **Sources of Sediment in Bulk Sweetened Condensed Milk.** C. A. Day, The Bennett Creamery Co., Ottawa, Kans. Milk Plant Monthly, *36*, 8: 66, 68, 70. 1947.

Sediment or extraneous matter may get into condensed milk from any of the following sources: (a) poorly cleaned equipment, (b) rust and sediment from water and steam pipes, (c) washing powders, (d) scouring pads, steel wool, metal sponges, brushes, and abrasives, (e) empty bungless barrels, (f) insects and rodents, (g) sugar sacks, and (h) sugar. G.M.T.

342. **Observations on the Viscosity of Sweetened Condensed Milk.** B. H. Webb, Division of Dairy Research Laboratories, Bureau of Dairy Industry, U. S. Dept. of Agr. Milk Plant Monthly, *36*, 7: 48, 50, 52. 1947.

Viscosity is one of the important indications of quality in sweetened condensed milk. The more heat to which sweetened condensed milk is subjected after condensing, the more viscous will the milk become. The viscosity increases with temperature and time of holding. Lower forewarming temperature (160° F.), adding cane or beet sugar at the close of the concentration process, avoidance of overheating toward the end of the process, avoidance of super-heating, cooling properly after condensing, and storing at a low temperature (60° F. or under) tend to keep the viscosity of the final product at a minimum. G.M.T.

343. **Changes in the Essential Amino Acid Content of the Proteins of Dry Skim Milk on Prolonged Storage.** A. Z. Hodson and G. M. Krueger, Pet Milk Co., Greenville, Ill. Arch. Biochem., *12*, 1: 51. Jan., 1947.

The essential amino acid content of freshly processed spray-dried skim milk was compared with that of dry skim milk stored at room temperature for 51 months in loosely covered containers. Microbiological assay showed that only those samples which had become dark and unpalatable had marked losses of arginine, histidine, lysine, and methionine. Insignificant differerences in amino acid composition were noted when old samples retained their white color, fresh taste, and appearance. H.J.P.

344. The Manufacture of Cultured Buttermilk. W. I. TRETSVEN, Dairy Advisory Service, Chicago, Ill. Milk Plant Monthly, *36*, 7: 24–26, 28. 1947.

The methods of making cultured buttermilk on a large scale are discussed. This body, whey separation, and presence of gas can be overcome by proper processing and handling. Stabilizers are suggested for increasing viscosity and preventing whey separation. Flavor may be enhanced by addition of 0.2% sodium citrate to the skim milk before pasteurization, and by addition of cream and a small amount of salt. G.M.T.

345. Manufacturing Cultured Sour Creams, Including a Nonperishable Cultured Sour Cream. W. I. TRETSVEN, Dairy Advisory Service, Chicago, Ill. Milk Plant Monthly, *36*, 8: 24–26, 40. 1947.

Producing a good cultured sour cream consistently day after day is a problem. The manufacturing procedure involves using a cream containing 15–25% fat, pasteurizing at 180° F. for 30 min., homogenizing at 3,000 lb. pressure at the pasteurization temperature, cooling to 70° F., inoculating with 0.5% culture, ripening from 10–18 hr., and then packaging. Viscosity sometimes is increased by the addition of spray-dried nonfat dry milk or concentrated skim milk. Rennet extract sometimes is used where homogenizing is not practiced. Gelatin (0.3%) may be used to increase viscosity, prevent whey separation, and impart other desirable qualities to the cultured cream. Other stabilizers may be used to prevent whey separation. G.M.T.

346. The Utilization of Whey. B. H. WEBB AND E. O. WHITTIER, Division of Dairy Research Laboratories, U. S. Dept. Agr. Milk Plant Monthly, *36*, 8: 88, 90, 92. 1947.

The authors have surveyed the field and present graphically, giving brief description and citations, 25 different ways in which whey may be utilized. G.M.T.

347. What Can Be Done With Whey? M. D. SANDERS, Swift & Co., Chicago, Ill. Milk Plant Monthly, *36*, 7: 44, 46. 1947.

Tremendous quantities of whey go to waste each year because of lack of means of economical utilization. The solution to the whey problem would be a large commercial outlet for the whey solids and a simple and economical means of processing the whey suitable for small cheese plants handling 10 to 20 thousand pounds of milk per day. As yet no outlet has been developed which will absorb the cost of transportation of raw whey or processing at the source. Numerous methods of utilizing whey in various by-products are given, but as yet these dispose of only a small percentage of the whey available. G.M.T.

DISEASES

348. The Resistance of Chronic Staphylococci Bovine Mastitis to Massive Penicillin Therapy. E. C. McCulloch. Amer. Jour. Vet. Res., *8*, 27: 173–177. April, 1947.

Treatment of 10 quarters of 7 cows chronically infected with *Staphylococcus aureus* served to test the efficacy of massive, repeated infusions of penicillin. Intramammary infusion of a total of 400,000 units per quarter, given in 4 infusions of 100,000 units at approximately 12-hr. intervals after each of 4 successive milkings, was followed by only a temporary reduction in number of staphylococci shed in the milk of treated quarters. There was no evidence of irritation due to the large amounts of the drug used, and milk yields were not significantly reduced following series of infusions. T.M.L.

349. Milk Fever (Parturient Paresis) as a Manifestation of Alkalosis. A. H. Craige, Jr., and I. V. Stoll. Amer. Jour. Vet. Res., *8*, 27: 168–172. April, 1947.

In a study of 12 cases of milk fever, evidence shows that treatment by calcium gluconate relieves acute symptoms rather rapidly and effectively, but the characteristic hypocalcemic condition often persists for some time. In an effort to supplement the present calcium gluconate treatment and to raise the blood calcium levels more rapidly, Chlor-Ethamine was given orally after the animals had regained locomotion. There is some indication that this treatment may be very useful, especially on animals that are subject to frequent relapse after an apparent cure.

Although hypocalcemia is a characteristic symptom of milk fever, it probably is not the fundamental physiologic defect; however, it appears to be secondary to a parturient alkalosis. T.M.L.

350. Vibronic Abortion in Cattle. W. N. Plastridge, L. F. Williams, and Dorothy Petrie. Amer. Jour. Vet. Res., *8*, 27: 178–183. April, 1947.

The examination of 72 fetuses from slaughtered cows of herds suspected of having vibrionic abortion revealed that 20 animals were positive for the infection. The annual abortion rate in 10 herds infected with "vibrio factus" averaged about 12%. Some evidence indicates that infection with "vibrio factus" also influences conception. Bulls may contract the disease. At the present time the method of detecting the infection by the agglutination test is not so accurate as that for Bangs' disease. T.M.L.

ICE CREAM

351. New Sanitary Practices and Controls. M. G. PEDERSON, El Paso, Tex. Internatl. Assoc. Ice Cream Mfrs., Prod. and Lab. Council Proc., *2*: 7–14. 1946.

Water may become a source of a bad sediment pad in ice cream. Air may be important, especially if the plant is located along an alley, if coal is handled in the plant, or if dusty streets are located near the plant. Air may be checked by filtering plant air through a filter cloth attached to a vacuum cleaner. Sediment may come from any ingredient of the mix, cleaning compounds, equipment, or packages.

The sanitarian looks closely at the hands and clothes of the employee and looks almost as closely at the clean-up job done at the end of the day's work. Flies may be controlled by the use of DDT; a 5% solution in oil or water emulsion will last for 9 days to 6 weeks. For other insects such as roaches and ants, rotenone and fluoride are recommended since DDT is not a cure-all for roaches. Proper plant construction may eliminate many of these pests. The several chemicals used by the Army during the war for control of rats are not effective against mice; nor will the construction of the building keep all of these out. P.S.L.

352. The Future of Concentrated and Dry Ice Cream Mixes. R. J. REMALEY, Kraft Foods Co., Chicago, Ill. Ice Cream Trade Jour., *43*, 6: 68. June, 1947.

Concentrated and dry ice cream mixes were made in large quantities during the last years of World War II. These products would keep for about 4 months at 100° F., but the life of the product could be increased by storing at a lower temperature. Since the war sales to the housewife and to the small ice cream manufacturer are increasing. When sugar and milk solids become more available, the small manufacturer may tend to discontinue the use of dry ice cream mix. In some places city ordinances requiring pasteurization of the reconstituted products before freezing have interfered with sales. Central and South American countries may provide enormous markets for these products.

The future for dry ice cream mix appears bright provided a good quality product is maintained and sales are regulated to insure freshness of the product. Workable regulations and a realistic attitude toward the economy of exportation will help promote the sale of concentrated and dry ice cream mix. W.H.M.

353. Corn Sweeteners, Their Place as an Ingredient in Our Post War Ice Cream. ANONYMOUS. Ice Cream Rev., *30*, 12: 45. July, 1947.

Scientists from many of the leading dairy schools, with a few important

exceptions, believe that corn sweeteners have won for themselves a permanent place in our postwar ice cream. Some of the reasons advanced are: (a) Corn sugar and corn sirups in particular definitely improve the body texture of ice cream. (b) They make it possible to build up the total solids of the mix at a reasonable cost with less danger of sandiness. (c) They facilitate the production of the heavier bodied, smooth-textured ice cream so much in demand at the present time. (d) The use of suitable combinations of sweetening agents makes it possible for the ice cream manufacturer to control the firmness and relative sweetness of ice cream. (e) Corn sweeteners normally are a relatively cheap source of solids.

Possible drawbacks to the continued use of corn sweeteners are: (a) Their use complicates the mix-making procedure by introducing one or more additional ingredients. (b) It is inconvenient to handle corn sirups in small plants. (c) Some types of dried corn sirups are difficult to handle because of their tendency to lump and cake during storage. (d) Some may impart an objectionable color or flavor to ice cream. Despite some possible drawbacks to the use of corn sweeteners in ice cream, it generally is agreed that these products permanently will supply a part of the sugar solids in the postwar ice cream. W.J.C.

354. Method of Manufacturing Ice Cream and Product Thereof. B. NELSON. (Assigned to Lanco Products Corp.) U. S. Patent 2,423,613, July 8, 1947 (17 claims). U. S. Patent Office Off. Gaz., *600,* 2: 256. 1947.

An ice cream ingredient consisting of a mixed glycerol diester of a higher fatty acid and an aromatic carboxylic acid is described. R.W.

355. Latest Developments in Hardening Ice Cream. R. H. THOKE, Chicago, Ill. Internatl. Assoc. Ice Cream Mfrs., Prod. and Lab. Council Proc., *2:* 15–18. 1946.

The older methods of hardening ice cream by means of ceiling, wall, and shelf ammonia pipes, with periodic defrosting, are messy and damaging to the building construction and insulation. The blast system of air circulation is objectionable to cooler labor. The unit cooler or blower system is sure to replace the older method because it is efficient, provides quick hardening, and is space saving. Defrosting of this newer system may be accomplished by: (a) intermittent water spray over the coil bank, (b) intermittent recirculation of warm air over the coil bank, and (c) continuous defrosting by recirculation of calcium brine over the coil bank. Cold air direction is well guided by using air ducts or, even better, by using draftless outlets such as anemostats. The use of tunnels at −40 to −50° F. with high air velocity for quick hardening of packaged goods may have serious economic disadvantages. Texture of ice cream is not improved by such treatment. P.S.L.

356. Latest Developments in Hardening Ice Cream. J. B. ORRELL, Philadelphia, Pa. Internatl. Assoc. Ice Cream Mfrs., Prod. and Lab. Council Proc., *2:* 18–23. 1946.

At one time the plant described used for hardening packaged ice cream a conveyor belt 6 ft. wide and 40 ft. long. This was discarded to save space. Skids now are used for carrying the ice cream and it is hardened at – 40° F. In the hardening room, vertical bins are used which permit separation of flavors but which require a 14-ft. ceiling. By this means a room may be cooled by using 26,000 ft. of 1.25-in. coils, where in the past 45,000 ft. of 2-in. coils were used in the same space. A suction header for these coils is placed near the ceiling. This arrangement permitted an increase from 12,145, 2.5-gallon can capacity to 23,000, and from 1,292 to 2,920 sq. ft. of floor-space. Much more space may be occupied by ice cream by using the vertical coil. The actual gain was 3.7 quarts per cu. ft. over the old system, or approximately 50%. Snow collecting on the coils easily may be scraped off or even swept off. To install this system, considerable height in the room is required. Rooms are maintained at – 20° F. For hardening brick molds, the molds are cut at – 15° F. Bulk ice cream can be hardened in 8 to 10 hr., although to accomplish this, temporary blowers are placed in the aisles of the hardening room each night. P.S.L.

357. Latest Developments in Hardening Ice Cream. H. BITTER, Toronto, Canada. Internatl. Assoc. Ice Cream Mfrs., Prod. and Lab. Council Proc., *2:* 23–25. 1946.

See Abs. 220, Jour. Dairy Sci., *30,* 7: A97. July, 1947.

358. Fruit Purees, Frozen Fruit Desserts and Velva Fruit. E. H. WIEGAND, Food Technology Dept., Oregon State College, Corvallis. Ice Cream Rev., *30,* 12: 52. July, 1947.

Specific directions for the preparation of fruit purees and for their use in the manufacture of frozen fruit desserts and Velva fruit are presented. A simple frozen puree, prepared by the freezing of pulped fruit with or without added sugar, is best adapted for use in ices and sherbets, Velva fruit, and soda fountain flavors. The pectinized puree, which is used in the production of ribbon ice cream, also can be used directly in the manufacture of fruit ice cream without further treatment. Detailed directions are given for the preparation of a pectinized puree, frozen puree desserts, and Velva fruit. W.J.C.

359. Developing Maximum Fruit Flavors in Ice Cream. D. G. SORBER, Albany, Calif. Internatl. Assoc. Ice Cream Mfrs., Prod. and Lab. Council Proc., *2:* 26–40. 1946.

Some fruits are outstanding in flavor and at least 20 kinds are suitable

for ice cream manufacture. Full maturity is essential for full flavor development. A disadvantage is that the fruit must be handled very carefully; it is difficult to harvest such fruits as apricots and peaches at one time because they do not ripen uniformly. Soft fruits may be prepared as purees; boysenberries ripen so rapidly that they can only be pureed. Since a portion of the peel aids the flavor of a peach, this fruit must be de-fuzzed before freezing. More fruits are adapted to pureeing than to crushing. Cantaloupes will oxidize rapidly if exposed to air and, therefore, are prepared by the use of a disintegrator which will blanket them from air. Copper and copper alloys and iron must be avoided. Iron and tannin form a gray color in ice cream. Zinc forms poisonous salts. Stainless steel is the best metal to use.

Peaches darken easily with exposure to oxygen and 0.25% ascorbic acid may be added as a preventative, although 0.10 to 0.15% may be sufficient. Number 10 tins to 30-lb. tins are highly desirable for peaches. This fruit may be frozen at −10° F. and stored at 0° F. or below. They should be defrosted at 40° F. and as long as 2 or 3 days allowed for thawing to prevent the definite flavor change taking place at higher temperatures. Apricots are important as frozen fruits, although the variety is not so important. The best are tree ripened and, when crushed, make a good topping.

Avocados may be used to a limited extent, although they darken easily. Fresh bananas may be frozen, and it appears that there will be an abundance of tree-ripened bananas soon. Blackberries vary greatly in quality. Boysenberries, loganberries, Johnsonberries, and Wilsonberries are of the same lineage as the blackberry. Cantaloupes are highly aromatic, can be pureed, and are high in vitamin C, but they must be protected from air or vitamin C will be destroyed. Both sweet and sour cherries may be frozen successfully but not so successfully pureed. Cranberry pulp, 1:1, is good frozen. The Guava contains as high as 1% vitamin C and comes in many varieties. Mangos have a highly aromatic flavor and probably a future as a puree. Nectarines are smooth-skinned peaches more pronounced in flavor, useful with peaches, and one variety is fine for sherbets. The orange is the most common flavor for sherbets. The passion fruit offers great possibilities as an ice cream fruit. Tangerines form an excellent sherbet base. The Santa Rose plum and the red raspberry are well adapted for freezing. P.S.L.

360. Do Winter Ice Cream Supply Shopping Early. C. D. DAHLE. Ice Cream Field, *50*, 1: 40, 43, 44. July, 1947.

Plastic cream, butter, butter oil, and frozen cream are available and now are being purchased for storage. The main point to consider in such purchases is "quality" and the factors affecting quality.

It is recommended that 92 or 93 score butter made from sweet cream

pasteurized at 170° F. for 30 min. be stored at 0° F. or lower. Plastic cream is more popular than butter for use in ice cream. Brief mention is made of butter oil and frozen cream. For best results, not over 50% of the fat in ice cream should come from the stored products mentioned here. Care also should be taken to prevent "oiling off"; if it does occur, the use of 0.10% glycerol monostearate or 0.30 to 0.50% dried egg yolk or its equivalent will restore whipping properties of mixes to normal. W.C.C.

361. Should We Lease or Own Retail Stores. ANONYMOUS. Ice Cream Rev., *30*, 12: 114. July, 1947.

When the question of store ownership vs. leasing was put to a group of operators of retail ice cream stores, opinions expressed were divided. In general the operators of a small number of stores who had been able to purchase suitable locations at a reasonable cost favored store ownership. On the other hand, operators of a large number of retail ice cream stores favored leasing rather than owning the property, believing that capital invested in real estate is less productive than when used to provide additional sales outlets for ice cream.

The trend among chain store organizations, as well as among the operators of a large number of retail ice cream stores, is toward leasing rather than ownership of the property. One organization on the West coast reports that they are in the process of selling their stores and taking back long-term leases on these same holdings, thereby releasing capital for further expansion. In the opinion of the operator it is not economically sound for a company with more than 5 stores to put its money into real estate. By turning over all leasing arrangements to a firm specializing in the development of chain store properties, this company has reduced the cost of its leases from an average of 12% to 7% per year. W.J.C.

MILK

362. Pasteurizing Plant Operations in Small Towns. ANONYMOUS. Milk Dealer, *36*, 9: 45, 46, 108–112. June, 1947.

America's new frontier for operators of milk pasteurizing plants, apparently, lies in the nation's rural communities of 800 to 1,500 population where raw milk has reigned supreme and consumer resistance to change consistently has thwarted the venturesome pasteurized milk distributor who sought the necessary business volume to make a pasteurization plant pay. The experiences of the Ambrose Dairy in Cornell, Wisconsin, are related to show the principal problems confronting the small dairy operator in a small community and how such problems may be solved. These problems include: (a) obtaining adequate financing of an improved business venture;

(b) overcoming what is sometimes called "The Psychology of the Small Town"; (c) management; (c) quality control; and (e) product diversification. C.J.B.

363. **Clean and Cold. Essentials in the Production of Quality Milk.** H. L. PENDLETON, Massachusetts Dept. of Agr. Milk Plant Monthly, *36*, 7: 73–74. 1947.

Two essentials for production of high quality milk are cleanliness of production and immediate and maintained refrigeration. Proper sanitation of all utensils with which milk comes in contact is imperative. Storage of rubber inflations in lye solution is recommended. Wetting agents have the property of penetrating the surface of rubber and thus are being used in the cleaning of milker inflations. The brushless age of dairy sanitation rapidly is approaching. G.M.T.

364. **Ten Common Causes of Excessive Sediment in Milk. Part 7. Sediment in Rinse Water.** C. B. A. BRYANT, Johnson and Johnson, Chicago, Ill. Milk Plant Monthly, *36*, 8: 98, 100–101. 1947.

The type of sediment sometimes found in milk may indicate that its source may be coming from the rinse water. Farm tests have shown that the rusty appearing sediment may get in the milk from pipes through the water used for rinsing. G.M.T.

365. **Is Mrs. Housewife Continuing to Buy Your Chocolate Flavored Milk?** C. F. BOWEY, Boweys, Inc. Milk Dealer, *36*, 9: 58–60. June, 1947.

The increase which has taken place in the use of chocolate flavored milk and the factors influencing its quality, price, and merchandising are discussed. C.J.B.

366. **What's the Outlook for Paper Containers?** J. L. DOLPHIN, Sealright Co., Inc. Milk Dealer, *36*, 8: 52–58. May, 1947.

The paper shortage largely is due to the fact that many industries that swung over to paper during the war, through necessity, are staying with paper because of convenience. This applies especially to shipping cartons. During the war additional paper mills and machinery for making paper could not be built; it takes 3 years to build a paper mill and to get raw materials, such as pulp, together. Expansion programs currently being executed will produce an additional 3 million tons of paper and paper board per year beginning with 1947, as compared to the capacity in 1945.

C.J.B.

367. Quaternary Ammonium Compounds as Preservatives for Milk. C. K. JOHNS AND H. V. PRITCHARD, Science Service, Dept. of Agr., Ottawa, Canada. Canad. Pub. Health Jour., *37*, 12: 500–504. Dec., 1946.

The possibility that quaternary compounds might be used as milk preservatives by unscrupulous persons has prompted this study. Four commercial compounds were compared with formaldehyde at their "critical concentration", *i.e.*, the amount in p.p.m. which could just be tasted after holding in fresh raw milk for 18 hr. at 60° F. These concentrations ranged from 70 to 560 p.p.m. for the four products. Formaldehyde could be detected at 25 p.p.m.

To determine the preservative effect at these concentrations, samples of fresh, raw milk were held at 60° F. for 18 hr. and then plated by the standard method. Methylene blue and resazurin reduction times also were determined. The four quaternary compounds were very much less efficient preservatives under these conditions. While each of them exerted a slight bacteriostatic action, these were extremely limited when compared to formaldehyde. The resazurin color numbers after 3 hr. incubation afforded a less variable indication of relative bacteriostasis than was furnished by the plate count and was somewhat more sensitive to small differences than was the methylene blue reduction time. O.R.I.

368. What Can Be Done to Even up Yearly Milk Production. R. COWAN, Seattle Milk Producers' Assoc., Seattle, Wash. Milk Dealer, *36*, 8: 70–74. May, 1947.

The following plans for evening up yearly production of fluid milk by producing dairymen are discussed: (a) Base and excess (surplus) plan; (b) straight contract with producers for a certain amount of milk each day the year around; and (c) increasing the price in the fall and winter months sufficiently over the spring price to encourage fall and winter production.

The base and excess plan has been in use for many years, and over a period of years it works toward the evening up of production, although not perfectly. The straight contract plan seems more adaptable to markets with large herds. Increasing the price in the fall and winter months would get results but probably would work only where there is a Federal Milk Marketing Order. "An even flow stabilizes the industry for both city milk producer, the factory producer, and it is the best assurance the consumer has to get quality milk at reasonably stabilized prices." C.J.B.

369. Homogenized Milk, Concentrated Milk Products and Other Developments. C. A. IVERSON, Dept. of Dairy Indus., Iowa State College. Milk Dealer, *36*, 8: 49, 50, 84–88. May, 1947.

See Abs. 303, Jour. Dairy Sci., *30*, 9: A129. Sept., 1947.

370. **Milk Plant Accounting.** F. W. Root, Woodlawn Farm Dairy, Wilkes-Barre, Pa. Milk Dealer, *36*, 8: 46, 112–117. May, 1947.

The relation and contribution of milk plant accounting to efficient management are discussed. Answers must be found to the following questions: (a) Are operations burdened with excessive charges for taxes, insurance, depreciation thus making the initial plant cost too high? (b) Are labor costs too high due to the plant being too large or too small for the volume handled? (c) Does labor maintain a fair standard of productive performance? Are the new employees carefully instructed as to their work and is the supervision adequate to maintain maximum performance? Are there any overmanned operations? (d) Is the plant designed for the most efficient method of handling operations? (e) Is the plant over-equipped, thus causing excess repairs and clean-up time? Are capable engineers available in the event of a breakdown? (f) Are supplies, such as cleaning, bottle caps and hoods, repair parts, and bottles, under inventory control so that amounts used can be checked against actual requirements for the volume handled? (g) Is there a daily accounting for products received, processed, and sold? Do these reports permit the detection of waste? (h) Do steam, refrigeration equipment, and motors throughout the plant have capacities for the most economical operation? Is the maintenance of all equipment on a routine basis which will insure a minimum of interrupted operations?

In conclusion the author states that the accountant can contribute to efficient management by becoming an interpreter instead of a recorder of business information. He should interpret in terms of the future and thus give management an opportunity to prepare for changes; he should become a cooperative finder of facts instead of a seeker of faults. C.J.B.

371. **Competing for the Consumer's Dollar.** W. Gerber, Whiting Milk Co., Boston, Mass. Milk Dealer, *36*, 8: 152–155. May, 1947.

The nation is drinking 30% more milk than ever before. The opening half of 1946 may be characterized as a highly sheltered seller's market. Price controls remained on milk and other dairy products while other so-called "market basket items" were freed of restrictions. Faced with higher costs, the housekeeper had to use more milk, cream, butter, and cheese. During the war years, too, the public became accustomed to using more dairy products to compensate for the shortages of other basic food staples. Servicemen and women came back from the war drinking more milk than ever before.

The approach to the problem of maintaining and increasing sales is discussed under the following heads: (a) The available market must continue to be educated to the value of milk, the need for increased consumption, and new ways of using milk by means of an all-out advertising campaign embracing all tested media. (b) We must redevelop selling skills. C.J.B.

372. **Device for Dispensing from an Inverted Milk Can.** L. BETHKE. (Assigned to Solar-Sturges Mfg. Co.) U. S. Patent 2,423,679, July 8, 1947 (7 claims). U. S. Patent Office Off. Gaz., *600*, 2: 272. 1947.

A device is described which clamps into the neck of milk cans, forming a base or support for the can when inverted and providing an air inlet and a valve-controlled spout for dispensing the liquid contents. R.W.

PHYSIOLOGY

373. **Cobalt Metabolism Studies. III. Excretion and Tissue Distribution of Radioactive Cobalt Administered to Cattle.** C. L. COMAR AND G. K. DAVIS, Florida Agr. Expt. Sta., Gainesville. Arch. Biochem., *12*, 2: 257. Feb., 1947.

When purebred Jersey steers on an adequate diet were fed labeled cobalt, 80% of the dosage was eliminated in the feces and 0.5% was found in the urine. Relatively high concentrations in the small intestine and intestinal lymph glands indicated the probable route of absorption. The liver was the chief storage organ; an animal sacrificed 5 days after cobalt ingestion contained 0.4% of the dose in the liver.

Labeled cobalt injected into the jugular vein disappeared rapidly from the blood; 65% of the dose was eliminated in the urine and about 30% in the feces. General distribution throughout the tissues occurred; up to 46% of the dose was found in the liver with subsequent excretion *via* the bile. High concentrations were found in the glandular organs. Small amounts of labeled cobalt appeared in the abomasum contents but practically none in the contents of the other stomach compartments. Cobalt administered by injection or fed to pregnant cows was transmitted across the placenta, primarily for storage in the liver of the fetus. The amount reaching the fetus is so small, however, that its significance as a reserve is open to question. H.J.P.

374. **A Galactogen from Beef Lung.** M. L. WOLFROM, D. I. WEISBLAT, AND J. V. KARABINOS, Ohio State Univ., Columbus, Ohio, and O. KELLER, Hoffman-LaRoche, Inc., Nutley, N. J. Arch. Biochem., *14*, 1 & 2: 1. July, 1947.

A dextrorotatory galactogen from beef lung was isolated and characterized. The polysaccharide is different from that obtained from the snail *Helix pomatia*. H.J.P.

SANITATION AND CLEANING

375. **Developments in Cleaning Compounds for the Dairy Industry.** L. H. MINOR, J. B. Ford Division, Wyandotte Chemicals Corp. Milk Dealer, *36*, 9: 49–56. June, 1947.

The developments in cleaning compounds for the dairy industry have been correlated closely with the improvement in methods of sanitation for the purpose of safeguarding public health. Forty-six years ago the use of modified soda cleaners for cleaning solutions eliminated soapy off-flavors in milk. Later the pasteurization of milk was accompanied by new cleaning problems which were solved by including silicates and simple phosphates in cleaning compounds. Another advance was made when it was found that the chemicals known as polyphosphates would sequester the mineral substances contained in hard water, thus preventing the formation of the undesirable precipitates. Still later the materials known as surface active or wetting agents were found to assist in obtaining a more rapid penetration of cleaning solutions into milk residues.

The progress made during the past 45 years in the flavor, quality, and sanitary control of milk and its products should be an inspiration for still greater improvements in cleaning, washing, standardizing, and development of germicidal products. C.J.B.

376. **Photocolorimetric Method for Determination of Quaternary Ammonium Salts.** E. L. COLICHMAN, Turco Products, Inc., Los Angeles, Calif. Indus. and Engin. Chem., Analyt. Ed., *19*, 6 : 430–431. June, 1947.

A method is described which consists of forming the quaternary ammonium-bromophenol blue salt in carbonate solution in the presence of an excess but definite critical concentration of dye. The color intensity of the solution is measured directly by photoelectric colorimeter without extracting the colored complex with an organic solvent. The difficulties associated with the use of organic solvents in extraction of color thus are avoided.

B.H.W.

377. **Sanitation at the Soda Fountain.** C. J. PALMER, Soda Fountain Manufacturers Assoc. Ice Cream Rev., *30*, 12 : 60. July, 1947.

The road to a greater prosperity for soda fountain operators is through the operation of a clean, attractive soda fountain. The growing consciousness on the part of the consuming public of possible dangers of infection from spoons, glasses, and similar utensils which have not been properly cleaned and sterilized is causing the public to withdraw its patronage from eating places which are not kept spic and span. Soda fountain operators who do not read the handwriting on the wall and see that their operations are above any possible criticism by a discriminating public will find themselves without customers. It simply is good business to establish voluntarily a reputation for cleanliness and sanitation. Additional patronage and the resultant higher profits which come to the clean, neat, attractive soda foun-

tain far outweigh the extra time, effort, and expense necessary to maintain such an operation. The sanitation program must start with the thinking of management and becomes a reality only when steps are taken to get results. W.J.C.

378. Methods of Washing, Sterilizing and Drying Cans. V. SCHWARZKOPF, The Lathrop-Paulson Company, Chicago, Ill. Milk Plant Monthly, *36*, 7: 30–32, 34, 46, 53. 1947.

The best method of washing, sterilizing and drying cans is the one which will most completely and economically remove or destroy bacteria present, remove the oil or milk solids, dry the can, protect the tin coating, and keep the can free from water and milk stone. The designer of can washers must know the following with regard to the cleaning compound which is used: (a) its reaction with water hardness, (b) its reaction with milk solids and milk fats, (c) optimum temperatures of use, (d) critical temperatures of use, (e) rinsing characteristics, and (f) effect on surface tension of the rinse water. The conventional method employing alkali detergent and the conservation method employing non-alkaline or acid cleaner now are used for washing, sterilizing and drying cans. The chief difficulties with the conventional method are: (a) continued re-use of the wash water, (b) failure to treat rinse water to prevent scale deposit, (c) high costs because of large volume of hot rinse water, (d) excessive residue contained in the finished cans, and (e) low efficiency in destroying bacteria because of low temperatures. With the conservation method, relatively clean wash water is used continuously; hot water is treated to prevent lime deposit; pumps, pipe lines, and machine are at maximum efficiency since there is no accumulation of lime deposits; cans are more nearly sterile because of high temperature without stone formation; residual alkali is kept at a minimum; and costs of water and steam are cut in half. G.M.T.

379. Control of Some Insects Affecting Farm Dairying. E. H. FISHER, College of Agriculture, University of Wisconsin, Madison. Milk Dealer, *36*, 9: 140–144. June, 1947.

The following sanitation operations are given for making the control of houseflies, stable flies, and hornflies easier and cheaper: (a) Have well-drained barnyards; flies breed in puddles of decaying straw and similar material. (b) Remove manure frequently (each day if possible) and spread it on the fields. (c) Place straw and hay stacks so that their bases are not continually wet; flies breed in wet straw and hay stacks. (d) Construct privies with a concrete vaunt, a lid on seat, a self-closing door, and screen to cover openings for light and ventilation. (e) Keep garbage cans covered. (f) Use screens on barn and milk house windows. Directions are given for using DDT to control flies and cattle lice. C.J.B.

380. Bottle Washing Problems. D. H. JACOBSEN, Cherry-Burrell Corp., Chicago, Ill. Milk Dealer, *36*, 9: 154–158. June, 1947.

Bottle washing is discussed under the following headings: soaker washer problems, importance of temperature, bottle washing compounds, scale prevention, cloudy bottles, bottle etching, and alkalis and lubrication in soaker washer. The author concludes that until uniform standards are established, it is well for milk plant operators to follow local standards on caustic concentration and then choose bottle washing compounds which provide the maximum in bottle-cleaning efficiency. The importance of free rinsing and scale-free operation also should be kept in mind. C.J.B.

381. Method of Cleaning Containers. M. E. PARKER AND W. BONEWITZ. (Assigned to P. W. and B. M. Bonewitz.) U. S. Patent 2,424,049, July 15, 1947 (2 claims). U. S. Patent Office Off. Gaz., *600*, 3: 437. 1947.

A method of cleaning containers, such as milk cans, is described which employs an aqueous solution of an organic acid at a temperature in excess of 190° F. to prevent accumulations of calcium and magnesium solids. R.W.

MISCELLANEOUS

382. Glass Block for Exterior Walls. ANONYMOUS. Milk Dealer, *36*, 8: 47, 106. May, 1947.

Glass block is particularly suited to milk processing plant use because it is impervious to moisture and water and is easily cleaned. It diffuses the light into the room, giving uniform illumination, has high insulation value, helps prevent infiltration of dust and dirt, and improves sanitation. Glass block has a "modern look" and is as modern as it looks. C.J.B.

383. Eliminating Fuel Waste. H. D. ELFRETH AND A. MACHARG. Cochrane Corp., Philadelphia, Pa. Milk Dealer, *36*, 9: 92–94. June, 1947.

The service engineer in his routine calls on power plants frequently is astonished at what appears to be a disregard of fuel saving possibilities in the average plant. He frequently notices that: (a) Exhaust steam is being discharged to the atmosphere instead of being used in a feedwater heater to raise the boiler feed temperature. (b) High temperature condensate is being discharged into low pressure receiving tanks vented to atmosphere or into open hotwells. (c) The blowdown from boilers is being discharged directly to waste instead of through a heat-reclaiming system. (d) Even in plants where feedwater heating equipment has been installed, faulty instal-

lation or operation occasionally prevents the securing of the saving for which the unit was purchased.

The following is suggested as a check list in determining the savings possible in any particular plant: (a) Maintain a high feedwater temperature. (b) Recover the heat in boiler blowoff water. (c) Return all condensate to the boiler. (d) Reduce moisture content of steam. (e) Check boiler water treatment. (f) Keep on the watch for steam and hot water leaks. (g) Provide insulation or lagging. (h) Practice preventive maintenance.

C.J.B.

384. New Developments in the Field of Refrigeration. W. H. MARTIN, Dept. of Mechanical Engineering, Oregon State College. Milk Dealer, *36*, 9: 134–138. June, 1947.

Evaporating temperature, discharge pressure, and capacity need to be watched to guard against inefficient refrigeration operation. Rules governing these conditions are given. After discussing the evaporation condenser, moisture in refrigeration systems, and refrigeration system controls, the author presents a table showing comparative data for 1 ton, 200 BTU per min. installation, using Freon 22, ammonia, and Freon 12. C.J.B.

385. Promises and Limitations of Electronics in the Dairy Industry. R. E. OLSEN, Taylor Instrument Co., Rochester, N. Y. Milk Indus. Found. Assoc. Bul., *39*, 15: 448–454. May, 1947.

The American Standards Association defines electronics as "that branch of science and technology which relates to the conduction of electricity through gases or in vacuo." The phenomenon was observed by Edison in 1883. In recent years we have had an accelerated development and application of electronic devices.

One of the first applications in the dairy field was the use of the vapor mercury lamp to increase the vitamin D potency of milk. Another application is the use of the so-called germicidal lamps. The electron microscope should be useful in bacteriological studies in the dairy field. Electronic heating has been useful in some other fields, but the pasteurization of milk at present can be accomplished more economically by other means. Many measurements, such as pressure, temperature, liquid level, and time, may be made with electronic devices, but frequently such devices are more complicated or expensive than an alternative method of measurement. Pressure measurement and timing of flow in a STHT pasteurizer are examples. The electronic principle for level controllers has been discarded for a form of power-amplifying transformer because of untimely failure of vacuum tubes for this application.

Temperature may be measured by an electronic device, but mercury

thermometers and recording thermometers seem to do the job more simply and inexpensively. E.F.G.

386. **What Is Quality?** W. VINCENT, U. S. Food and Drug Administration, Denver, Col. Natl. Butter and Cheese Jour., *38*, 8: 47. Aug., 1947.

See Abs. 243, Jour. Dairy Sci., *30*, 7: A105. July, 1947.

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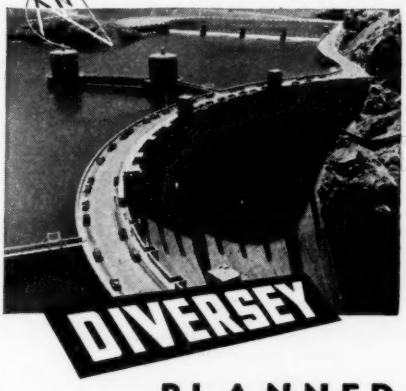

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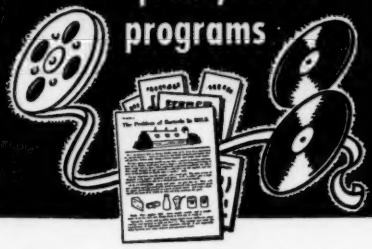

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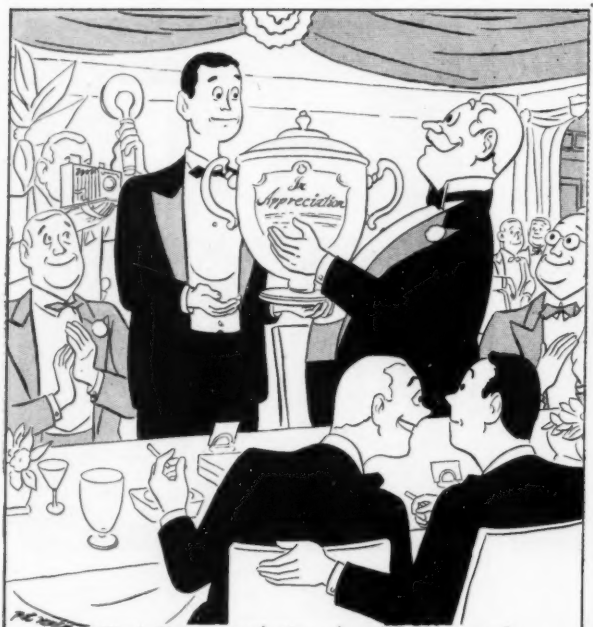

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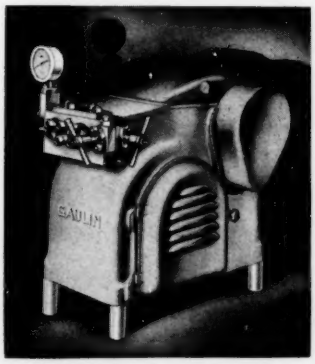

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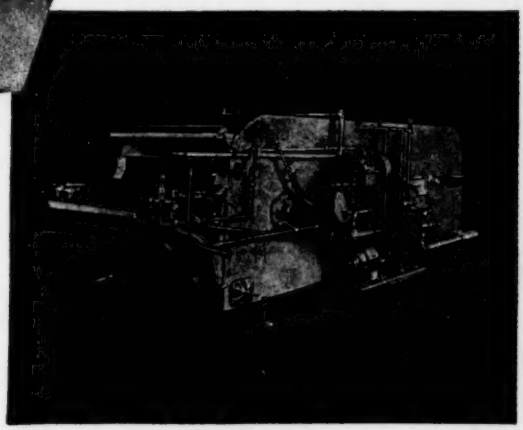

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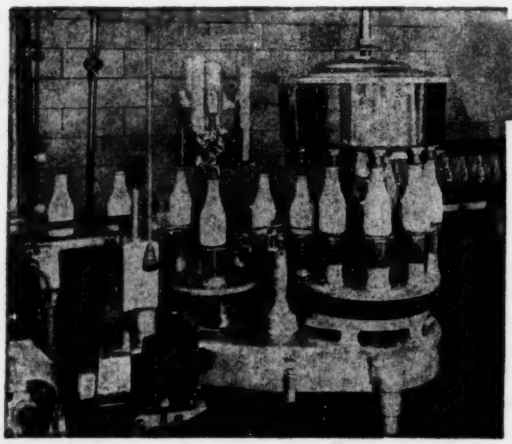

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